NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037 (250)
March 1990

National Aeronautics and Space Administration

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NASA SP-7037(250)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 250)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in February 1990 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 420 reports, journal articles and other documents originally announced in February 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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Category 12 Engineering 127
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Category 13 Geosciences 137
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 137
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 139
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 141
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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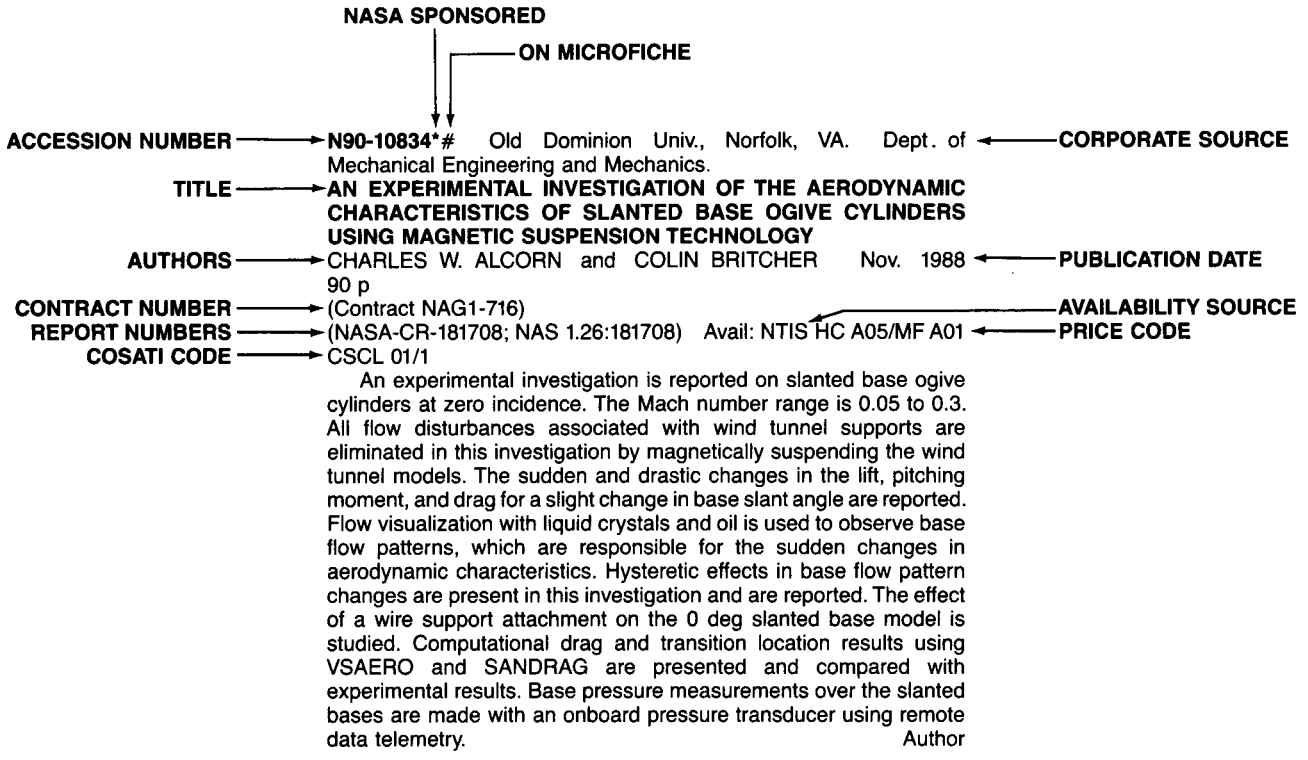
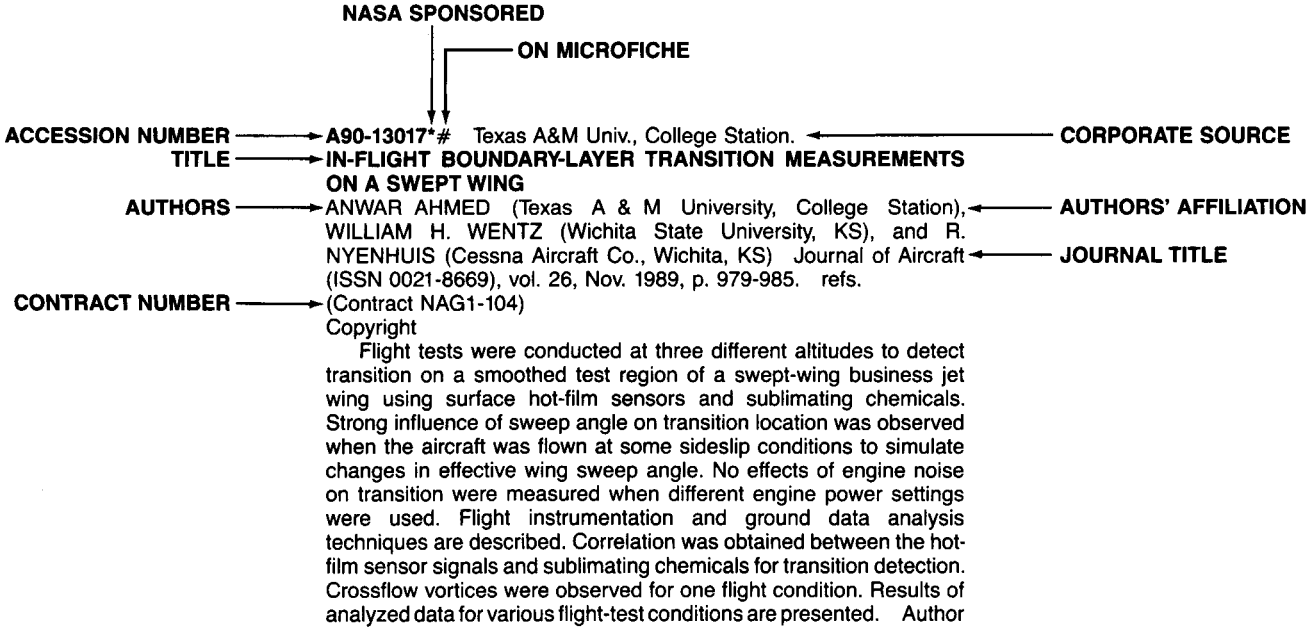
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 250)

MARCH 1990

01

AERONAUTICS (GENERAL)

A90-13557*# National Aeronautics and Space Administration, Washington, DC.
RECENT RESULTS AND MAJOR ACTIVITIES IN THE NASA BALLOON PROGRAM
W. VERNON JONES (NASA, Space Physics Div., Washington, DC) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 10 p. refs
(IAF PAPER 89-468) Copyright

The Balloon-Borne Particle Astrophysics Magnet Facility and the Max '91 Solar Balloon Program exemplify NASA's state-of-the-art uses of instrumented balloons in scientific research. The latter program will involve the carriage of sophisticated solar study instrumentation over the mid-latitudes and Antarctica; four test flights of this balloon from Australia to South America are contributing to the development of a long-duration flight-support system with global tracking, command, and telemetry at both mid and high latitudes. O.C.

A90-14336
INSTALLATION AND IMPLEMENTATION OF AN EXTRUSION CELL IN AIRCRAFT INDUSTRY UTILIZING GROUP TECHNOLOGY
JON PAUL TURVEY (Cessna Aircraft Co., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 8 p.
(SAE PAPER 891025) Copyright

The results of installing a cell designed to fabricate extrusion parts for aircraft industry complete except for chemical processing and paint are described. The installation sequence is shown and the consequent higher productivity, at all levels of the manufacturing organization is demonstrated. Comparisons are made with conventional part manufacturing processes. Strengths and weaknesses of the cell are examined with regard to electronic routing, operator's responsibilities, and management and union response. C.D.

A90-14371
DESIGN FOR MAINTAINABILITY
GORDON T. VAIL (Townsend Co., Carrollton, TX) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 6 p.
(SAE PAPER 891079) Copyright

Maintenance costs for the support of operational aircraft programs make up a large portion of the overall costs. This paper describes some basic processes that can be applied during design phases of the engine development program that can reduce such costs. The methods presented herein have been successfully used in the past and have been proven to be effective in reducing costs. Author

A90-14659
THERMOPLASTIC COMPOSITE FIGHTER FORWARD FUSELAGE
ROBERT B. OSTROM, STEPHEN B. KOCH, and DEBRA L. WIRZ-SAFRANEK (Lockheed Composite Development Center, Burbank, CA) SAMPE Quarterly (ISSN 0036-0821), vol. 21, Oct. 1989, p. 39-45.
Copyright

A total of five intermediate service temperature thermoplastic matrix resins have been used in a technology validation program which used thermoplastic composites to construct a forward fuselage section structure representative of advanced fighter designs. Several different tooling systems were used to define the tool surfaces used for molding the various structural components from prepregs. An account is given of the lessons learned in the course of tooling, forming, consolidating, and joining the various composite structure elements; competing techniques and technologies have been evaluated to a high degree of certainty for future cost-competitive airframe primary structure manufacture. O.C.

A90-14800#
THE SOVIETS' FRENCH REVELATION. II - AIRCRAFT
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 27, Nov. 1989, p. 42-46.
Copyright

The exhibition of the Su-27 interceptor at the Paris Air Show is described. The Su-27 interceptor, NATO code-named Flanker, was exhibited in both single- and two-seat variants, conservatively equipped with Lyulka AL31F turbofans and a fly-by-wire (FBW) flight control system that can minimize trim drag. Like the MiG-29, the Flanker is designed to operate from dispersed bases such as short, poor, and repaired fields, to keep an offensive going, and spread and hide forces. The MiG-29s in Paris were specifically made for display and marketing in the West. Other aircraft such as the Su-25, the Su-28, and the An-225 Mechta made their Western debut in Paris, including the Mi-28 combat helicopter. Commercial aircraft rounded out the Soviets' Paris push. Displayed were the Tu-204, a twin in the 757 class, and the four-engine Il-96, similar in size to the Airbus A-300. C.E.

A90-14997#
INNOVATION IN GENERAL AVIATION
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 27, Aug. 1989, p. 30-35.
Copyright

The future of general aviation is discussed. Consideration is given to improving the aerodynamics of aircraft, the use of new composite materials, and advances in avionics. The market for unpressurized single-engine aircraft and advances in the design of the aircraft are examined. I.F.

N90-11692*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
REVIEW AND ANALYSIS OF THE DNW/MODEL 360 ROTOR ACOUSTIC DATA BASE
R. A. ZINNER, D. A. BOXWELL, and R. H. SPENCER (Boeing Helicopter Co., Philadelphia, PA.) Nov. 1989 26 p Presented at the 15th European Rotorcraft Forum, Amsterdam, Netherlands, 12-15 Sep. 1989

(NASA-TM-102253; A-89213; NAS 1.15:102253; USAAVSCOM-TM-89-A-002) Avail: NTIS HC A03/MF A01 CSCL 01B

A comprehensive model rotor aeroacoustic data base was collected in a large anechoic wind tunnel in 1986. Twenty-six microphones were positioned around the azimuth to collect acoustic data for approximately 150 different test conditions. A dynamically scaled, blade-pressure-instrumented model of the forward rotor of the BH360 helicopter simultaneously provided blade pressures for correlation with the acoustic data. High-speed impulsive noise, blade-vortex interaction noise, low-frequency noise, and broadband noise were all captured in this extensive data base. Trends are presentes for each noise source, with important parametric variations. The purpose of this paper is to introduce this data base and illustrate its potential for predictive code validation.

Author

N90-12495# Naval Postgraduate School, Monterey, CA.
ESTIMATING THE RELATIONSHIPS BETWEEN THE STATE OF THE ART OF TECHNOLOGY AND PRODUCTION COST FOR THE US AIRCRAFT M.S. Thesis
ROBERT E. LOWE Jun. 1989 80 p
(AD-A212127) Avail: NTIS HC A05/MF A01 CSCL 01/3

The primary objective is to determine relationships that exist between production cost and the state of the art of technology and extensions in technology for high-technology systems. The data sample selected for study was U.S. military tactical aircraft. The central methodology used in the analysis of the aircraft data base includes: the development of measures for the state of the art of technology and the level of technology advance that exists within U.S. fighter and attack aircraft programs; the development of measures for each aircraft program's production cost; and the application of various statistical procedures (regression analysis) to test specific hypotheses and build models to explain the relationships between technology and cost. General conclusion from this study are that significant relationships do in fact exist between aircraft production cost and specific technology measures. GRA

N90-12496# Institute for Defense Analyses, Alexandria, VA.
THE NASA EXPERIENCE IN AERONAUTICAL R AND D: THREE CASE STUDIES WITH ANALYSIS Final Report, Jan. 1985 - May 1987
JOHN S. LANGFORD, III Mar. 1989 227 p
(AD-A211486; AD-E501144; IDA-R-319; IDA/HQ-87-32596)
Avail: NTIS HC A11/MF A01 CSCL 01/1

Recent policy studies have failed to provide adequate guidance for planning and evaluating the nation's program of aeronautical research and development. In particular, the government's use of experimental systems to bridge the gap between laboratory research and operational systems remains controversial. This thesis used retrospective examinations of NASA's work in aircraft noise reduction, powered-lift technology, and hypersonic flight technology to analyze the impact and effectiveness of such programs under four general circumstances that may justify government involvement in a market-driven economy. It concludes that the NASA proof-of-concept program has had mixed results, with technical goals more successfully accomplished than policy goals. The public benefits of the successes, however, far outweigh the costs of the disappointments. The thesis concludes that such demonstration programs in aeronautical research and development should continue, with a series of analytical and institutional changes to couple them more closely with policy goals. GRA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A90-13775#
AERODYNAMIC HEATING IN SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION REGIONS INDUCED BY BLUNT FINS
SHIGERU ASO (Kyushu University, Fukuoka, Japan), ANZHONG TAN (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China), and MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 49, June 1989, p. 109-124. refs

A study is conducted on aerodynamic heating in the interaction regions of shock waves and turbulent boundary layers induced by blunt fins with semicylindrical leading edges. The study is performed under the conditions of Mach number 4, 1.2 MPa total pressure, a 0.66 wall temperature to total temperature ratio, and Reynolds number of 1.3 x 10 to the 7. Blunt fins with leading-edge diameters of 6 mm and 10 mm are used to examine the influence of leading-edge diameter on the pressure and heat transfer rate distributions. The flow fields are visualized by the Schlieren method and the oil flow technique. The results show that two significant peaks are observed in the surface pressure and heat transfer rate distributions. The peaks are located along the reattachment line. It is also shown that the major scale factor governing the entire flow field is the leading-edge diameter of the blunt fin.

S.A.V.

A90-13783
THE EFFECT OF TRAILING EDGE EXTENSIONS ON THE PERFORMANCE OF THE GOETTINGEN 797 AND THE WORTMANN FX 63-137 AEROFOIL SECTION AT REYNOLDS NUMBERS BETWEEN 3 X 10 TO THE 5TH AND 1 X 10 TO THE 6TH
A. ITO (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 93, Oct. 1989, p. 283-289. refs
Copyright

A90-13785
THE EFFECT OF FLOW CURVATURE ON THE AERODYNAMIC CHARACTERISTICS OF AN OGIVE-CYLINDER BODY
D. I. T. P. LLEWELYN-DAVIES (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 93, Oct. 1989, p. 301-310. refs
Copyright

Low speed wind tunnel and whirling arm facility tests have been used to compile the pressure distributions over a 6:1 fineness ratio ogive cylinder model; these pressure distributions were integrated to obtain the local normal force loading distribution along the body and the overall normal-force and pitching moment involved in the center of normal-force. The primary difference among aerodynamic characteristics between the two test methods was a significant positive increase in normal-force loading over the entire afterbody in curvilinear motion, which varied little with the magnitude or sign of the pitch angle. O.C.

A90-13786
UNIFIED SUPER/HYPERSONIC SIMILITUDE FOR STEADY AND OSCILLATING CONES AND OGIVES
KUNAL GHOSH (Indian Institute of Technology, Kanpur, India) Aeronautical Journal (ISSN 0001-9240), vol. 93, Oct. 1989, p. 311-322. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

A unified similitude for super/hypersonic flow has been given for non-slender cones and quasicones with attached shock. The similitude space has been shown to be orthogonal to the bow

shock and an accurate scaling law for cone flows of different Mach numbers has been provided. A constant density solution has been obtained which gives simple formulas for shock angle and pressure on a cone. This leads to an axisymmetric shock expansion theory which incorporates the effect of profile curvature of an ogive in inviscid flow or a cone in viscous flow whose boundary layer displacement thickness is known a priori. The hypersonic formulas for pitching moment derivatives of oscillating cones and ogives have been adjusted to extend them to supersonic Mach numbers. Author

A90-13787
EXPERIMENTAL INVESTIGATIONS OF EFFECTS OF THE STAGGER ANGLE ON SECONDARY FLOWS IN PLANE COMPRESSOR CASCADES [EXPERIMENTELLE UNTERSUCHUNGEN ZUM EINFLUSS DES STAFFELUNGSWINKELS AUF DIE SEKUNDAERSTROEMUNGEN IN EBENEN VERDICHTERGITTERN]
UDO STARK (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 55, Sept. 1989, p. 135-148. In German. refs
Copyright

Results of experiments carried out with two plane compressor cascades of different stagger angle (30 and 50 deg) are discussed. The objective was to learn more about the effects of the stagger angle on side wall boundary layers and secondary flows in compressor cascades. The three-way experiment included wake measurements in the center plane of the cascade for all inlet angles; wake measurements along the half span of a blade for one inlet angle each; and oil flow pictures of the tunnel side wall and both sides of a blade for all inlet angles. Different results were obtained for both cascades. Only those of the weakly staggered cascades indicated equivalence in size and development along span. By contrast, the highly staggered cascade had unexpected results. The behavior of the boundary layers on the tunnel side walls is the key for understanding the results. These boundary layers are found to be always separated with differently located separation lines and with different consequences. C.E.

A90-13788
EXPERIMENTAL INVESTIGATIONS ON THE SPATIAL AND TIME-DEPENDENT STRUCTURE OF PART-LOAD RECIRCULATIONS IN CENTRIFUGAL PUMPS [EXPERIMENTELLE UNTERSUCHUNGEN ZUR RAEUMLICHEN UND ZEITLICHEN STRUKTUR DER TEILLAST-REZIRKULATIONEN BEI KREISELPUMPEN]
BERND STOFFEL (Darmstadt, Technische Hochschule, Federal Republic of Germany) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 55, Sept. 1989, p. 149-152. In German. refs
Copyright

Detection of the onset of recirculations at a centrifugal pump impeller inlet has been measured using air as the flowing fluid. The measured data have been analyzed in the time and frequency domain by means of hot-wire anemometry. The influence of different upstream velocity distributions on the onset of recirculations at the inlet is discussed. C.E.

A90-14091* High Technology Corp., Hampton, VA.
GOERTLER VORTICES IN SUPERSONIC AND HYPERSONIC BOUNDARY LAYERS
R. E. SPALL and M. R. MALIK (High Technology Corp., Hampton, VA) Physics of Fluids A (ISSN 0899-8213), vol. 1, Nov. 1989, p. 1822-1835. refs
(Contract NAS1-18240)
Copyright

The problem of Goertler vortices in compressible boundary layers over concave walls is considered. At O(1) wavelengths, the instability is governed by parabolic partial differential equations that are solved numerically to determine the effect of various initial conditions on the development of Goertler vortex instability in compressible boundary layers. The results show that both the velocity and temperature fluctuations may lead to a Goertler vortex. The vortex growth rates determined from the present method are found to differ somewhat from those given by a normal mode solution. At both the supersonic and hypersonic Mach numbers, cooling has a small destabilizing effect. In addition, the most unstable disturbances shift toward lower wavelengths because of thinning of the boundary layer. The results also show that compressibility has a stabilizing effect on the Goertler instability, while the effect of an adverse pressure gradient is found to be destabilizing. The behavior of the Goertler vortex structure with Mach number is also examined. At hypersonic Mach numbers, vortices are located near the edge of the boundary layer for adiabatic wall conditions. However, the entire boundary layer is affected when the wall is cooled. Author

A90-14331
SPANWISE DISTRIBUTION OF LIFT AND DRAG AT HIGH ANGLES OF ATTACK
MELVIN H. SNYDER, WANG YONG, and GEORGE B. ROSS (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 8 p.
(SAE PAPER 891019) Copyright

Experimental results are presented which indicate that, at angles of attack above stall, spanwise lift and drag distributions of finite wings differ considerably from classic aerodynamic theory. The increase of lift force toward the wingtip is partially ascribable to 'side-edge' vortex lift; the use of leading-edge extension cuffs will further change the spanwise lift distribution above the wing's stall angle. On the basis of these results, a new wing incorporating a system of lateral controls is being tested to determine whether an extension of effective control at angles of attack beyond stall can be achieved. O.C.

A90-14332
AN ITERATIVE NON-LINEAR LIFTING LINE MODEL FOR WINGS WITH UNSYMMETRICAL STALL
BARNES W. MCCORMICK (Pennsylvania State University, University Park) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 11 p. refs
(SAE PAPER 891020) Copyright

A numerical nonlinear lifting line model is presented which predicts the behavior of a wing beyond the stall given two-dimensional airfoil data. The model, although relatively simple, appears to predict fairly complex stall effects including hysteresis and unsymmetrical spanwise lift distributions with partial-span stall. The numerical model runs rapidly on an IBM-Compatible PC and does not require any extensive CFD-type of calculations. Because of its speed and apparent accuracy in modeling the physical behavior of a stalled wing, it may find application to the simulation of airplane motion beyond the stall. Although the numerical model was developed independently, here a similar approach has been tried previously by others. These previous efforts and a comparison with the present results are discussed briefly. Author

A90-14333
DEVELOPMENT OF A STALL IMPROVEMENT PACKAGE FOR THE GULFSTREAM IV
HUGH S. BRUNER (Gulfstream Aerospace Corp., Savannah, GA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 11 p.
(SAE PAPER 891021) Copyright

A package of aerodynamic devices has been developed in order to enhance the stall characteristics of the Gulfstream IV. The package consists of an array of small vortilons beneath the leading edge plus a small stall strip inboard which control the spreading of airflow separation at stall. This package permits the aircraft to tailor the prestall and poststall characteristics without compromising the wing's excellent transonic cruise characteristics. The mechanisms by which the package works are explained and the flight test program is briefly reviewed. The results show improvement in the Gulfstream's stall characteristics. C.D.

A90-14438
NUMERICAL SIMULATION OF THREE-DIMENSIONAL FLOW AROUND PARACHUTE CANOPIES [CHISLENNOE MODELIROVANIE PROSTRANSTVENNOGO OBTEKANIIA KUPOLOV PARASHIUTOV]
P. A. BARANOV, M. I. NISHT, and A. G. SUDAKOV (Voenno-Vozdushnaia Inzhenernaia Akademiia, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 308, no. 2, 1989, p. 304-307. In Russian. refs
Copyright
The discrete-vortex method is used to calculate both separated and nonseparated three-dimensional flows around thin shells of complex geometry. The surfaces in the flow are represented by a set of triangular frames, while the wake is modeled by a quadrangular frame. A version of the division of the parachute surface into triangular vortex elements is presented. B.J.

A90-14563
VARIABLE-VELOCITY FLOW AT THE INITIAL MIXING SECTION IN A DIFFUSER CHANNEL [TECHENIE NERAVNOMERNOGO PO SKOROSTI POTOKA NA NACHAL'NOM UCHASTKE SMESHENIIA V DIFFUZORNOM KANALE]
V. N. GRUZDEV and R. IU. EMALETDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 31-34. In Russian. refs
Copyright
Results of measurements of velocity, temperature, and turbulence intensity and scales in plane diffusers with a nonuniform velocity field at the inlet are analyzed. The results obtained indicate that the intensity of turbulent transfer at the initial section depends only slightly on the diffuser channel geometry. It is concluded that the mixing of comoving jets in the initial section of a diffuser can be calculated using laws valid for cylindrical channels. V.L.

A90-14564
CONSTRUCTION OF A STRAIGHT SINGLE-ROW AIRFOIL LATTICE BY THE METHOD OF QUASI-SOLUTIONS FOR INVERSE BOUNDARY VALUE PROBLEMS [POSTROENIE PRIAMOI ODNORIADNOI RESHETKI PROFILEI METODOM KVAZIRESHENII OBRATNYKH KRAEVYKH ZADACH]
N. B. IL'INSKII, A. V. POTASHEV, and G. R. TAIURSKAIA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 35-38. In Russian. refs
Copyright
A new approach is proposed for solving the problem of hydrodynamic lattice profiling on the basis of a given velocity distribution as a function of the arc coordinate of the airfoils making up the lattice. The approach is based on the concept of quasi-solution in the theory of inverse boundary value aerohydrodynamic problems for an individual airfoil section. Results of numerical calculations are presented. The analytical solution proposed here has been implemented in software written in FORTRAN. V.L.

A90-14566
A NUMERICAL METHOD FOR CALCULATING SUPERSONIC NONISOBARIC JETS [CHISLENNYI METOD RASCHETA SVERKHZVUKOVYKH NEIZOBARICHESKIKH STRUI]
A. M. MOLCHANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 42-45. In Russian.
Copyright
An efficient implicit marching procedure is developed for solving stationary equations of gas motion. The method is unconditionally stable and avoids the need for block or scalar matrix inversion. Although flow of a nonviscous gas only is examined here for the sake of simplicity, the method can be easily extended to viscous flows. Details of the numerical solution and some calculation results are included. V.L.

A90-14577
EFFECT OF THE INLET DIAMETER AND NECK EDGE RADIUS ON THE FLOW COEFFICIENT OF STRAIGHT-GENERATRIX NOZZLES [VLIIANIE DIAMETRA VKHODA I RADIUSA SKRUGLENIIA VKHODNOI KROMKI GORLOVINY NA KOEFFITSIENT RASKHODA SOPEL S PRIAMOLINEINYMI OBRAZUIUSHCHIMI]
G. V. ABALAKOV, V. M. CHEFANOV, and A. P. GERASIMOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 78-80. In Russian. refs
Copyright
Experimental data are presented on the effect of the relative inlet diameter and neck edge radius on the flow coefficient of straight-generatrix nozzles in the Reynolds number range 2 x 10 to the 5th - 9 x10 to the 6th. Based on these data, the geometrical characteristics and applications of nozzles are determined. A relative inlet diameter of 2 + or - 0.5 and a neck edge radius of 0.005 or less are recommended for critical flowmeter nozzles; the flow coefficient of such nozzles will be 0.95, with a relative error of + or - 0.5 percent in the Reynolds number range investigated. V.L.

A90-14578
EFFECT OF THE ROUGHNESS OF DEPOSITS IN A COMPRESSOR CASCADE ON THE FLOW LAG ANGLE [VLIIANIE SHEROKHOVATOSTI OTLOZHENII V KOMPRESSORNOI RESHETKE NA UGOL OTSTAVANIIA POTOKA]
IU. N. MAL'TSEV and V. G. SHAKHOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 80-82. In Russian.
Copyright
The mechanism by which the surface roughness of deposits in compressor cascades affects the flow lag angle is examined with reference to the results of wind tunnel tests on plane compressor cascades with variable artificially created deposits. The flow rate and blading parameters were selected as close as possible to those of real compressors. It is found that, for a fixed angle of attack, the flow lag angle increases with the deposit roughness. The lag angle also increases with the increasing density of the cascade. V.L.

A90-14579
CALCULATION OF CONE DRAG [RASCHET SOPROTIVLENIIA KONUSA]
O. P. SIDOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 82-84. In Russian. refs
Copyright
Empirical formulas are obtained which make it possible to calculate the drag coefficient of a cone without using inaccurate graphic dependences for Mach 0-5 and aspect ratios of 1.3-7.2. The Mach number range is divided into five sections, with formulas for each section connected by the values of functions and their first derivatives. The derivation of the formulas is presented. V.L.

A90-15151
WING BOUNDARY LAYER CALCULATION AND ITS APPLICATION TO AIRCRAFT DESIGN
HANLING BAO (Beijing Polytechnic University, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 2, Aug. 1989, p. 145-154. refs
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A new method for calculating three-dimensional compressible laminar and turbulent boundary layers on practical wings is described. A nonorthogonal coordinate system proposed by Cebeci (1979) is used, and a secondary coordinate transformation is suggested to overcome the difficulties which arise when negative transverse velocities appear locally. Several computed results for a C-5A aircraft wing and an F-8 supercritical wing are given, and comparisons with other methods and with experimental data are made. Author

A90-15227#
RECENT NAVIER/STOKES CALCULATIONS IN APPLICATIONS
H. YOSHIHARA (Office of Naval Research, Tokyo, Japan) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 221-227.

The capabilities and limitations of current Navier-Stokes codes for fluid-dynamics simulations are reviewed on the basis of sample computations. Results for (1) transonic flow with shock-induced separation on a swept wing, (2) high-lift supersonic flow over a delta wing, and (3) and hypersonic flow on the wing/fuselage of an aerospace plane in cruise are presented in graphs and diagrams and discussed in detail. The need for better modeling techniques to treat incipient and developed turbulence, hypersonic turbulence, and highly swept shocks is stressed. T.K.

A90-15231#
SUPERSONIC/HYPERSONIC FLOW PAST WEDGE AND PLANE OGIVE IN OSCILLATION
KUNAL GHOSH (Indian Institute of Technology, Kanpur, India) and MADHUSUDAN MURTHY (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 255-261. refs

A90-15232#
SEPARATED FLOW OVER SLENDER WING, BODY AND WING-BODY COMBINATION
S. AIKAT and N. SINGH (Indian Institute of Technology, Kharagpur, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 263-270. refs

In the present paper methods for the analysis of separated flow from bodies have been developed. An attempt has been made to describe the flow pattern past wings of different aspect ratio at high angles of attack. The separation from the fuselage like body is a little difficult to predict and some salient features have been discussed while developing the prediction method. The results have been compared with the available theoretical and experimental values. Author

A90-15233#
COMPUTATION OF TRANSONIC SEPARATED FLOW USING THE EULER EQUATIONS
S. SAHA (Indian Institute of Technology, Kharagpur, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 271-275.

Leading edge separated flow about a slender delta wing at 15 deg incidence and a match number of 0.9 has been computed by solving the Euler equations. The computed pressure distribution and total pressure loss contours show the presence of the separated vortex. The lift and drag coefficients obtained agree fairly well with experimental values. Author

A90-15235#
NUMERICAL SOLUTION OF UNSTEADY NAVIER-STOKES EQUATIONS FOR LAMINAR/TURBULENT FLOWS PAST AXI-SYMMETRIC BODIES AT ANGLE OF ATTACK
N. S. MADHAVAN and V. SWAMINATHAN (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 281-285.

The validity of the thin layer Navier-Stokes equations, in which the viscous derivatives are retained only in the direction normal to the wall has been tested and confirmed in several flow field computations particularly in the context of high Reynolds number flows. In the present paper, the thin layer Navier-Stokes equations together with an algebraic turbulence model are solved using MacCormack's predictor-corrector time-marching numerical scheme for axisymmetric flow past cylinder-flare and cone-cylinder geometries at various angles of attack at near flight Reynolds numbers. The results obtained for surface pressure distribution and skin friction coefficient from different flow field computations using the software developed and made operational on the CDC CYBER 170/730 computer of VSSC for the purpose were compared with experimental and earlier computed values. Author

A90-15237#
TRANSONIC FLOW OVER A SINGLE WEDGE
S. SANTHAKUMAR (Indian Institute of Technology, Madras, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 293-296. refs

The pressure distribution on a single wedge kept in transonic flow has been obtained by various authors on solving TSP equation exactly. In this paper, an approximate method has been used to calculate this pressure distribution. The method is based on a linearized equation which nevertheless simulates the TSP equation in the neighborhood of the airfoil. The result shows good agreement with exact results for the lower part of the transonic region. Author

A90-15238#
WAKE-BOUNDARY LAYER INTERACTION
V. RAMJEE, E. G. TULAPURKARA, and R. RAJASEKAR (Indian Institute of Technology, Madras, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 297-300. refs

The interactions between a turbulent boundary layer on a flat wall and the wake of a streamlined body as well as that of a bluff body of the same drag force are studied. The height of the lower edge of the wake from the wall is the same in the both cases. Mean velocity and longitudinal velocity fluctuations are presented at different downstream locations. Computations are carried out using a k-epsilon model of turbulence. The development of the boundary layer, the wake of airfoil, and its mixing with the boundary layer are numerically well-predicted. Author

A90-15240#
LEADING EDGE FLAP INFLUENCE ON AERODYNAMIC EFFICIENCY
S. K. PATEL, S. C. GUPTA, and A. P. VALVADE (Institute of Armament Technology, Poona, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 305-308.

A90-15241#
THE CHARACTERISTIC DECAY REGION OF A CLASS OF THREE-DIMENSIONAL WALL JETS
B. H. LAKSHMANA GOWDA (Indian Institute of Technology, Madras) and G. PADMANABHAM (Madras Institute of Technology, India) (National Conference on Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 309-315. refs

The characteristic decay (CD) regions of three-dimensional turbulent wall jets generated from orifices having shapes of various segments of a circle are described in this paper. The influence of geometry on the decay rate of the maximum velocity and the length of the CD region is brought out. The results are compared with those for rectangular geometries and the differences in the mechanism of the formation of the CD region for the two types are discussed. The maximum velocities decay at a much faster rate for the present class of geometries compared to those for rectangular shapes. Author

A90-15242#
NUMERICAL SIMULATION OF SUPERSONIC AND HYPERSONIC TURBULENT COMPRESSION CORNER FLOWS USING PNS EQUATIONS
N. S. MADHAVAN and V. SWAMINATHAN (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India) (National Conference on

Aerodynamics, 4th, Madras, India, Dec. 1988) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, Nov.-Dec. 1988, p. 317-322. refs

A90-15624
CALCULATION OF FLOW PAST DELTA WINGS IN THE THIN SHOCK LAYER APPROXIMATION [K RASCHETU OBTEKANIIA TREUGOL'NYKH KRYL'EV V PRIBLIZHENII TONKOGO UDARNOGO SLOIA]
V. N. GOLUBKIN and V. V. NEGODA Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Oct. 1989, p. 1530-1537. In Russian. refs
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The thin shock layer method is used to solve the problem of hypersonic flow at angle of attack past a delta wing of small aspect ratio, with the bow shock detached from the leading edge. Numerical results are approximated by simple analytical formulas. The accuracy of the results obtained is estimated. V.L.

A90-15739#
EULER SOLUTIONS WITH A MULTI-BLOCK STRUCTURED CODE
ANAND KUMAR (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, May 1988, p. 89-95. refs

Multiblock schemes enhance the scope of application of computational fluid dynamics to present-day complex configurations. With multiblock grid generation, embedded grids, and different equations in different domains, it should be possible to resolve the main features of flow over a complete aircraft with a grid containing about a million cells. Basic steps in the coding of multiblock schemes are described. Euler solutions for the vortex-dominated flow over a cropped delta wing are presented. These solutions show separation from the leading edge and formation of a leeside vortex. B.J.

A90-15740#
FULL-POTENTIAL CALCULATIONS USING CARTESIAN GRIDS
S. S. DESAI, R. RANGARAJAN, J. P. SINGH, and K. S. RAVICHANDRAN (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, May 1988, p. 97-103. refs

The full-potential equation in non-conservative form is solved in stretched Cartesian grid to obtain transonic solutions for flows past airfoils, axisymmetric bodies, wings and wing-body combinations. The main feature of the method is the use of suitable stretching functions to map the infinite physical domain into a finite computational domain. Computed results are promising and have underscored the simplicity of the Cartesian grid approach while assuring reasonable accuracy. Author

A90-15741#
COMPUTATION OF FLOW OVER AIRFOILS UNDER HIGH LIFT SEPARATED FLOW CONDITION
J. P. SINGH, R. RANGARAJAN (National Aeronautical Laboratory, Bangalore, India), and M. A. RAMASWAMY (Indian Institute of Science, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, May 1988, p. 105-110. refs

A90-15745#
DEVELOPMENT OF BLUFF BODY WAKE IN A LONGITUDINALLY CURVED STREAM
V. RAMJEE, E. G. TULAPURKARA, and R. RAJASEKAR (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, May 1988, p. 139-144. refs

Measurements of mean velocity and longitudinal turbulent fluctuations in the wake of a square cylinder are carried out in a straight duct and in a curved duct. The velocity profiles of the wake in the curved duct are asymmetric. The thickness of the shear layer is higher on the inner side than on the outer side. The inner side is the portion of the flow between the center line of the curved duct and the wall nearer to the center of the curvature. The intensity of the longitudinal turbulence fluctuations is enhanced on the inner side of the flow and not appreciably affected on the outer side. Author

A90-15820
CONVERGENCE PROPERTIES OF HIGH-REYNOLDS-NUMBER SEPARATED FLOW CALCULATIONS
S. G. RUBIN and A. HIMANSU (Cincinnati, University, OH) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 9, Nov. 1989, p. 1395-1411. refs
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The accelerated pressure-relaxation scheme developed by Rubin and Reddy (1983) for the reduced Navier-Stokes equations is applied to the flow over a smooth bump and trough; fine meshes are employed to investigate the reasons for computational divergence observed previously. The governing equations and boundary conditions are given; the numerical discretization and the relaxation scheme are explained; and the results are presented in a series of graphs and characterized in detail. The apparent 'laminar flow breakdown' is found to be controllable by moderate wall suction and is tentatively attributed to a physical (rather than merely numerical) instability related to HF fine-grid modes which are not resolvable via the present modeling technique. T.K.

A90-15821
NUMERICAL SIMULATION OF AN IMPINGING JET ON A FLAT PLATE
SHU-HAO CHUANG (National Chunghsing University, Taichung, Republic of China) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 9, Nov. 1989, p. 1413-1426. refs
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Two-dimensional normal impinging jet flowfields, with or without an upper plate, were analyzed by employing an implicit bidiagonal numerical method. The Jones-Launder K-epsilon two-equation turbulent model was employed to study the turbulent effects of the impinging jet flowfield. The upper plate surface pressure, the ground plane pressure and other physical parameters of the momentum flowfield were calculated at various jet exit height and jet inlet Reynolds numbers. These results were compared with those of Beam and Warming's numerical method, Hsiao and Chuang, and others, along with experimental data. The potential core length of the impinging jet without an upper plate is longer than that of the free jet because of the effects of the ground plane, while the potential core length of the impinging jet with an upper plate is shorter than that of the free jet because of the effects of the upper plate. This phenomenon in the present analysis provides a fundamental numerical study of an impinging jet and a basis for further analysis of impinging jet flowfields on a variable angle plate. Author

A90-15849
EXPERIMENTAL STUDY OF 2D/3D INTERACTIONS BETWEEN A VORTICAL FLOW AND A LIFTING SURFACE
D. FAVIER, CH. MARESCA, and A. CASTEX (Aix-Marseille II, Universite, Marseille, France) European Journal of Mechanics, B/Fluids (ISSN 0997-7546), vol. 8, no. 5, 1989, p. 397-430. Research supported by the Service Technique des Programmes Aeronautiques. refs
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Unsteady effects involved in two kinds of aerodynamic interaction are investigated by means of two-dimensional and three-dimensional flow configurations. Both consist of a receiving airfoil R placed downstream of an emitting airfoil E. One of the airfoils is in fore-and-aft oscillatory motion. In each two-dimensional or three-dimensional flow configuration, the typical interaction features are studied on both the impinging vortical flow influenced by R and on the aerodynamic response of R submitted to the vortical flow. The R behavior is deduced from measurements performed on the overall aerodynamic coefficients and on local pressure and skin friction distributions. A comparative study is conducted on steady and unsteady mean quantities over the period, and also on the corresponding steady values obtained with E and

R at rest. The significance of the two-dimensional and three-dimensional unsteady effects associated with each flow configuration is thus pointed out and discussed, as a function of the geometric incidence of R both at low and high values.
Author

A90-15889* Purdue Univ., West Lafayette, IN.
THREE-DIMENSIONAL AERODYNAMICS OF AN ANNULAR AIRFOIL CASCADE INCLUDING LOADING EFFECTS
S. FLEETER, R. C. STAUTER, and S. R. MANWARING (Purdue University, West Lafayette, IN) Experiments in Fluids (ISSN 0723-4864), vol. 8, no. 1-2, Oct. 1989, p. 49-58. Research supported by NASA. refs
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A series of experiments are described which investigate and quantify the effect of loading on the three-dimensional flow through a subsonic annular cascade of cambered airfoils. At two levels of loading, detailed data quantify the cascade inlet velocity, the intrapassage flow field, the airfoil surface pressure distributions, the exit flow field, and the total pressure loss distributions. Aerodynamic loading is shown to strengthen the radial pressure gradient, the passage vortex structure, the vortex-endwall boundary layer interactions, and the losses. Author

A90-16101
DEVELOPMENT PROCESS OF TURBULENCE IN A ROUND-NOZZLE AIR JET
SHINICHI YUU, TOSHIHIKO UMEKAGE, and YASUMITSU FURUKAWA (Kyushu Institute of Technology, Kitakyushu, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 32, Nov. 1989, p. 532-539. refs
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A series of measurements were made simultaneously by using arrays of hot-wire anemometers with X-probes. The data show the rows consisting of doughnut-type large-scale vortices and frequent pairing, which results in larger vortices. The interaction of these vortices beyond the jet centerline breaks the doughnut-type large-scale vortices and forms three-dimensional medium-sized and small-sized vortices. The flow is randomized through this process. Some large-scale vortices continue to pair and form the configuration of counterrotating vortices approximately alternating on opposite sides of the jet centerline in the region far from the nozzle. Author

A90-16104
STUDIES ON SUPERSONIC RADIAL FLOW BEHAVIOR IN DISK CHANNEL
DEWASISH BISWAS, HIROYUKI YAMASAKI, TAKAO MATSUI, YOSHINORI SAITO, and SUSUMU SHIODA (Tokyo Institute of Technology, Yokohama, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 32, Nov. 1989, p. 574-582. refs
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A supersonic radial flow in a disk channel is studied. Under the high stagnation pressure condition, effects of both the stagnation pressure and the channel height on the radial static pressure distribution are investigated. The pressure recovery through the pseudoshock, its length, the velocity profile and the thickness of the boundary layer were also measured. The results have shown that the supersonic region extends downstream with the increase of the stagnation pressure. However, the transition from the supersonic flow to subsonic flow occurs at the region further upstream than that predicted by the normal shock relation. The pressure recovery through the pseudoshock is found to be lower compared to that of a normal shock, particularly at a high, free-stream Mach number. In addition, the axially asymmetric form of the pseudoshock was observed. Furthermore, the measured static pressure, velocity distribution and the boundary layer thickness at the supersonic region agree well with the results of the two-dimensional calculation. Author

A90-16105
A STUDY ON SURGE AND ROTATING STALL IN AXIAL COMPRESSORS - A SUMMARY OF THE MEASUREMENT AND FUNDAMENTAL ANALYSIS METHOD
HIROSHI ISHII and YASUSHIGE KASHIWABARA (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Kandatsu, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 32, Nov. 1989, p. 583-590. refs
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In multistage axial compressors used for gas turbine engines, it is important to understand unsteady behaviors such as surge and rotating stall. The purpose of this study is to develop a practical analytical method for both surge and rotating stall in axial compressors. In this paper, firstly, some characteristics of the unsteady phenomena in axial compressors derived from the measurements of test compressors are summarized. Secondly, a numerical method for the unsteady phenomena is described, assuming incompressible flow. A feature of the method is solving the fluid equations by Galerkin's method with the circumferential flow distortion expressed in the form of a high-order Fourier series. Finally, the usefulness of the method, using some results from parameter-vary computations and comparisons with the measured results in a 3-stage test compressor, is examined. Author

A90-16332#
COMPUTATION OF THE THIN-LAYER NAVIER-STOKES EQUATIONS FOR A 2D FLOW
A. LAFON and J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1989, p. 21-36. refs
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Viscous laminar two-dimensional hypersonic flows are simulated numerically by computation of the thin-layer Navier-Stokes equations. An upwinding technique is used with flux splitting for a perfect gas. Computed data are presented that emphasize the importance of the accuracy of the scheme and of the tightness of the mesh in the boundary layer. A comparison is also made with a boundary-layer calculation. Also, in the case of a mainly supersonic flow, the governing equations are made hyperbolic-parabolic in the flow direction, and the previous algorithm is transformed into a marching method in this direction. Author

A90-16367#
CALCULATION OF FLOWFIELDS IN SIDE-INLET RAMJET COMBUSTORS WITH AN ALGEBRAIC REYNOLDS STRESS MODEL
T.-M. LIOU (National Tsing Hua University, Hsinchu, Republic of China) and Y.-H. HWANG Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Nov.-Dec. 1989, p. 686-693. Previously cited in issue 18, p. 2996, Accession no. A88-44725. refs
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N90-11695*# Notre Dame Univ., IN.
THE STRUCTURE OF SEPARATED FLOW REGIONS OCCURRING NEAR THE LEADING EDGE OF AIRFOILS - INCLUDING TRANSITION Semiannual Status Report, period ending 30 May 1989
May 1989 33 p
(Contract NSG-1419)
(NASA-CR-185853; NAS 1.26:185853) Avail: NTIS HC A03/MF A01 CSCL 01A

Laser Doppler Velocimeter data, static pressure data, and smoke flow visualization data was obtained and analyzed to correlate with separation bubble data. The Eppler 387 airfoil was focused on at a chord Reynolds number of 100,000 and an angle of attack of 2 deg. Additional data was also obtained from the NACA 663-018 airfoil at a chord Reynolds number of 160,000 and an angle of attack of 12 deg. The structure and behavior of the transition separation bubble was documented along with the redeveloping boundary layer after reattachment over an airfoil at low Reynolds numbers. The understanding of the complex flow phenomena was examined so that analytic methods for predicting their formation and development can be improved. These analytic

techniques have applications in the design and performance prediction of airfoils operating in the low Reynolds number flight regime. Author

N90-11696# National Aerospace Lab., Tokyo (Japan). V/STOL Aircraft Research Group.
WIND TUNNEL TEST OF CAD USB-STOL SEMI-BORNE PROTOTYPE
MASAHIRO OKUYAMA, HITOSHI TAKAHASHI, KAKUTOSHI FUJIEDA, TOSHIMI FUJITA, and AKIHITO IWASAKI Mar. 1987 34 p In JAPANESE
(NAL-TM-566; ISSN-0452-2982; JTN-88-80061) Avail: NTIS HC A03/MF A01

The National Aerospace Laboratories (NAL) is researching and developing an experimental fan-jet Short Take-Off and Landing (STOL) plane. Aerodynamic research on the shape of the STOL plane was started in 1983. Research on aerodynamic elements was completed and the obtained results were fed to the existing Computer Aided Design (CAD). Based on its program, the shape of the main wing of the plane was designed. A prototype having the main wing shape obtained with CAD was fabricated during 1984 and 1985. Described here are the results of wind tunnel tests that were conducted to determine the basic aerodynamic characteristics of the prototype under the new design. Tests of each flap mode with no wind load, effects of Vortex Generator (VG) with no wind load, effects of a deflector nozzle, effects of the Upper Surface Blowing (USB) flap angle with ventilation, effects of front and rear flap angles, and VG effects with ventilation were analyzed. Data to determine the characteristics of the three longitudinal components of force during crusing, taking off and landing modes was also obtained. A comparison of the data with the experimental data of the STOL plane ASUKA was made. NASDA

N90-11697# National Aerospace Lab., Tokyo (Japan). Second Airframe Div.
ACOUSTIC-THERMAL ENVIRONMENT FOR USB FLAP STRUCTURE. REPORT 1: GROUND SIMULATION TEST RESULTS
MASAAKI SANO, KOUICHI EGAWA, and SYUNJI ENDOH Jan. 1987 16 p In JAPANESE
(NAL-TM-567; ISSN-0452-2982; JTN-88-80062) Avail: NTIS HC A03/MF A01

Upper Surface Blowing (USB) flap structure, which is one of the high-lift generating units in the low-noise Short Take-off and Landing (STOL) aircraft ASUKA, characteristically receives great thermal and acoustic loads. In terms of the design, an acoustic load test was made in the laboratory, with partial structure models to get various basic data. At the same time, it was confirmed that there was not any damage due to acoustic fatigue or harmful deformation. The design conditions of USB flap structure, however, were set under various hypothetical factors. Furthermore, the test conditions with the partial structure model were limited by a load device. For these reasons, it was necessary to obtain more accurate design data for acoustic fatigue-proof design. The USB flap acoustic and thermal environment and its structure response characteristics were measured, as part of the ground simulation test made in National Aerospace Laboratory (NAL) Kakuda Laboratory in November 1981 and September 1982 with a view to grasping the total characteristics of USB high-lift unit. In addition to the measurement results, the initial design conditions and partial structure model test results are evaluated. NASDA

N90-11699*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTER SIMULATION OF AIRCRAFT AERODYNAMICS
MAMORU INOUYE Oct. 1989 11 p Presented at the 27th Aircraft Symposium, Fukuoka, Japan, 18-20 Oct. 1989; sponsored by Japan Society for Aeronautical and Space Sciences
(NASA-TM-102221; A-89227; NAS 1.15:102221) Avail: NTIS HC A03/MF A01 CSCL 01A

The role of Ames Research Center in conducting basic aerodynamics research through computer simulations is described. The computer facilities, including supercomputers and peripheral equipment that represent the state of the art, are described. The methodology of computational fluid dynamics is explained briefly. Fundamental studies of turbulence and transition are being pursued to understand these phenomena and to develop models that can be used in the solution of the Reynolds-averaged Navier-Stokes equations. Four applications of computer simulations for aerodynamics problems are described: subsonic flow around a fuselage at high angle of attack, subsonic flow through a turbine stator-rotor stage, transonic flow around a flexible swept wing, and transonic flow around a wing-body configuration that includes an inlet and a tail. Author

N90-11700*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF THE WIDE-FIELD SHADOWGRAPH TECHNIQUE TO ROTOR WAKE VISUALIZATION
THOMAS R. NORMAN and JEFFREY S. LIGHT Oct. 1989 20 p Presented at the 15th European Rotorcraft Forum, Amsterdam, Netherlands, 12-15 Sep. 1989
(NASA-TM-102222; A-89229; NAS 1.15:102222) Avail: NTIS HC A03/MF A01 CSCL 01A

The wide field shadowgraph technique is reviewed along with its application to the visualization of rotor wakes. In particular, current experimental methods and data reduction requirements are discussed. Sample shadowgraphs are presented. These include shadowgraphs of model-scale helicopter main rotors and tilt rotors, and full scale tail rotors, both in hover and in forward flight. Author

N90-11701*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EXPERIMENTAL INVESTIGATION OF HELICOPTER ROTOR HUB FAIRING DRAG CHARACTERISTICS
D. Y. SUNG, M. B. LANCE (Planning Research Corp., Hampton, VA.), L. A. YOUNG, and R. H. STROUB Sep. 1989 60 p
(NASA-TM-102182; A-89096; NAS 1.15:102182) Avail: NTIS HC A04/MF A01 CSCL 01A

A study was done in the NASA 14- by 22-Foot Wind Tunnel at Langley Research Center on the parasite drag of different helicopter rotor hub fairings and pylons. Parametric studies of hub-fairing camber and diameter were conducted. The effect of hub fairing/pylon clearance on hub fairing/pylon mutual interference drag was examined in detail. Force and moment data are presented in tabular and graphical forms. The results indicate that hub fairings with a circular-arc upper surface and a flat lower surface yield maximum hub drag reduction; and clearance between the hub fairing and pylon induces high mutual-interference drag and diminishes the drag-reduction benefit obtained using a hub fairing with a flat lower surface. Test data show that symmetrical hub fairings with circular-arc surfaces generate 74 percent more interference drag than do cambered hub fairings with flat lower surfaces, at moderate negative angle of attack. Author

N90-11704*# Bolt, Beranek, and Newman, Inc., Cambridge, MA.
SOME IMPLICATIONS OF THE ISOTROPIC MOMENTARILY FROZEN ASSUMPTIONS FOR THE SPAN-MAT PROGRAM Final Report
W. D. MARK Jun. 1986 29 p
(Contract NAS1-16521)
(NASA-CR-181937; NAS 1.26:181937; BBN-TM-938) Avail: NTIS HC A03/MF A01 CSCL 01A

Potential tests using turbulence velocity histories measured in the SPAN-MAT Program are outlined to determine validity of the homogeneous, momentarily frozen assumptions for the vertical turbulence velocity component and the homogeneous, isotropic, momentarily frozen assumptions for the horizontal turbulence velocity components. In addition, methods are reviewed for prediction of the crosscorrelation function between any two spatially separated turbulence velocity components using the homogeneous, isotropic, momentarily frozen assumptions and measurements of

the transverse and longitudinal turbulence velocity components.
Author

N90-11705# United Technologies Research Center, East Hartford, CT.
INVESTIGATION OF ADVANCED MIXER-EJECTOR EXHAUST SYSTEM Progress Report No. 3, 15 Apr. - 15 Jul. 1989
2 Aug. 1989 6 p
(Contract N00014-88-C-0654)
(AD-A211943; UTRC/R89-957928-3) Avail: NTIS HC A02/MF A01 CSCL 21/2

A combined experimental and analytical investigation is being conducted to study advanced mixer-ejector exhaust systems. The program is designed to provide benchmark experimental data relative to several advanced mixer-ejector exhaust system configurations; in addition, analytical flowfield development and plume assessment calculations was performed. Exhaust mixing, ejector pumping, and the mixer-ejector exit plane 3-D velocity field was investigated. A slot nozzle ejector configuration was investigated under a gas dynamic research program, in order to provide a baseline with which to compare mixer-ejector results. The JETPATH code was used to calculate flowfield development downstream of the mixer-ejector for the purpose of generating aerodynamic input for plume assessment calculations. Plume assessment calculations was performed using the IPAT code. In addition, an experimental compressibility assessment of convoluted exhaust nozzle mixing effectiveness was performed. This involves low speed testing of an advanced mixer nozzle which was tested previously at a supersonic operating condition. The compressibility assessment assisted a parallel contract to develop improved prediction procedures for vortical flowfield development downstream of convoluted trailing edge configurations. GRA

N90-11706# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
UNSTEADY AERODYNAMICS WITH APPLICATIONS TO FLIGHT MECHANICS Final Report, 1 Apr. 1984 - 31 Mar. 1989
HOLT ASHLEY Jun. 1989 20 p
(Contract AF-AFOSR-0099-84; AF PROJ. 2307)
(AD-A211944; AFOSR-89-1136TR) Avail: NTIS HC A03/MF A01 CSCL 01/1

Unsteady airload measurements have been made on a series of low aspects ratio delta wings subjected to transient pitch motions. These data have been qualified and discussed in several publication which are listed. In addition a discussion on the relevance of unsteady transient airloads to flight mechanics is included. GRA

N90-11707# Stanford Univ., CA. Dept. of Mechanical Engineering.
ACTIVE CONTROL OF UNSTEADY AND SEPARATED FLOW STRUCTURES Final Technical Report, 15 Apr. 1986 - 14 Apr. 1989
JOHN K. EATON and DENNIS J. KOGA May 1989 61 p
(Contract AF-AFOSR-0159-86; AF PROJ. 2307)
(AD-A212109; AFOSR-89-1210TR) Avail: NTIS HC A04/MF A01 CSCL 01/1

The objective of the research program was to formulate an active flow control method to change the vorticity and convection characteristics of a modelled dynamic stall vortex. Flow visualization, surface pressure and laser Doppler anemometer measurements were obtained. A potential flow model was developed as a state estimator and several flow control strategies were examined. GRA

N90-11709# ESDU International Ltd., London (England).
NORMAL-FORCE-CURVE AND PITCHING-MOMENT-CURVE SLOPES OF FOREBODY-CYLINDER COMBINATIONS AT ZERO ANGLE OF ATTACK FOR MACH NUMBERS UP TO 5
Apr. 1989 22 p Supersedes ESDU-86029 and ESDU-88026
(ESDU-89008; ESDU-86029; ESDU-88026; ISBN-0-85679-679-4; ISSN-0141-397X) Avail: ESDU

This Data Item 89008, an addition to the Aerodynamics Subseries, uses data drawn from the literature to produce semi-empirical correlations for the aerodynamic characteristics of cone and ogive forebodies, either sharp or with varying degrees of spherical blunting, on cylindrical afterbodies. The correlations provide the two slopes as the sum of three contributions: the inviscid loading distribution at angle of attack, the changes caused by the boundary layer displacement thickness, and the skin friction contribution. A fully turbulent boundary layer is assumed and the correlations are expected to apply to all axisymmetric forebody shapes whether or not there is a smooth-surface transition from the forebody to the cylinder. The correlations are presented graphically and the ranges of geometries and flow conditions studied are tabulated. Two worked examples illustrate their application in practice. ESDU

N90-11710# Centre Aeroporte de Toulouse (France).
PERFORMANCE AND QUALITY OF A WING TYPE PARACHUTE: PARAMETRIC ANALYSIS Final Report [ETUDE PARAMETRIQUE DES PERFORMANCES ET DES QUALITES DE VOL D'UN PARACHUTE DE TYPE AILE]
PATRICK CHAVANON Nov. 1988 159 p In FRENCH
Sponsored by the Ministere de la Defense, Paris, France
(REPT-88-19; ETN-89-95024) Avail: NTIS HC A08/MF A01

The parametric study of the quality and performance of a (wing) type parachute, is reported. The aim of the analysis is the improvement of the parachute equilibrium and control in operating conditions. In the scope of the work, the aerodynamic coefficients and efforts and the simulation program are discussed. The suspending rope lengths, the parachute surface, and the parachute setting are taken into account. The landing and pulling back dynamics are investigated. ESA

N90-11711# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abteillung Instationaere Aerodynamik.
STEADY AND UNSTEADY POTENTIAL FLOW AROUND THIN ANNULAR WINGS AND ENGINES WITH SIMULATION OF JET ENGINE FLOW
EDGAR KATZER Feb. 1989 84 p In GERMAN; ENGLISH summary
(DFVLR-FB-89-18; ISSN-0171-1342; ETN-89-95313) Avail: NTIS HC A05/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Federal Republic of Germany, 32 deutsche marks

The unsteady incompressible flow around oscillating jet engines and ring airfoils is analyzed numerically. A thin axisymmetric surface approximates the geometry, and the jet is simulated by a vortex cylinder. A new and efficient Fourier-panel method is derived by a Fourier decomposition of the flow which allows reduction of the problem by one dimension. A higher order vorticity distribution on the body represents the flow and extremely accurate results are obtained for a few panels. The unsteady flow is calculated with a time marching procedure. The influences of frequency diameter and jet on the unsteady forces and moments is investigated for jet engines and ring airfoils displaying harmonic heave and pitch oscillations. Empirical approximations valid for small diameters are derived. It is found that there are vanishing influences of the jet on the aerodynamic forces and only minor influences on the moments for engines with small diameters. Highly nonlinear influences of the jet and oscillation frequency appear with increasing diameter. The importance of these results in designing the extreme high-bypass engines of future aircraft is stressed.
ESA

N90-11712# Cranfield Inst. of Tech., Bedford (England). College of Aeronautics.
THE DETERMINATION OF THE AERODYNAMIC CHARACTERISTICS OF AN OGIVE-CYLINDER BODY IN SUBSONIC, CURVED, INCOMPRESSIBLE FLOW, AND AN ASSESSMENT OF THE EFFECT OF FLOW CURVATURE
D. I. T. P. LLEWELYN-DAVIES Dec. 1987 117 p
(Contract RAE-2028/131-XRAW)
(REPT-87-13; ISBN-0-947767-90-8; ETN-89-95575) Avail: NTIS HC A06/MF A01; Cranfield Inst. of Technology, College of

Aeronautics, Cranfield, Bedford MK43 0AL, England 7.50 Sterling pounds

Tests on a fineness ratio ogive-cylinder body made in a curved flow are described. Theoretical estimates are made of the aerodynamic characteristics of the model using the SPARV panel method, and slender-body and linear theory. The pressure distributions over the model are measured over a pitch range of -6.4 to 11.6 degrees measured relative to the nominal flow direction at the center of the model. The local loadings and overall loads are obtained by successive integration of the pressures. The experimental results show that unexpectedly high loadings are present over the whole of the afterbody and these dominate the aerodynamic characteristics giving high normal-force and a rearward centre of pressure position as compared with the results obtained from tests made in the straight flow provided by a windtunnel. ESA

N90-11713# Cranfield Inst. of Tech., Bedford (England). College of Aeronautics.
INCOMPRESSIBLE FLOW ABOUT ELLIPSOIDS OF REVOLUTION
P. A. T. CHRISTOPHER Feb. 1988 21 p
(REPT-88-02; ISBN-0-947767-86-X; ETN-89-95576) Avail: NTIS HC A03/MF A01; Cranfield Inst. of Technology, College of Aeronautics, Cranfield, Bedford MK43 0AL, England 7.50 sterling pounds

A derivation of the exact equivalent source and doublet distributions, associated with the flow around a prolate ellipsoid of revolution, is presented. The derivation provides a valuable alternative approach to the classical one, does not require a knowledge of the theory of spherical harmonics, and lends itself to a ready comparison with slender-body theory. ESA

N90-12500*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
NUMERICAL SIMULATION OF UNSTEADY ROTATIONAL FLOW OVER PROPFAN CONFIGURATIONS Semiannual Status Report, 1 May - 30 Nov. 1989
R. SRIVASTAVA and L. N. SANKAR Nov. 1989 33 p Presented at the AIAA 28th Aerospace Sciences Meeting and Exhibit, Reno, NV, 8-11 Jan. 1990
(Contract NAG3-730)
(NASA-CR-186037; NAS 1.26:186037) Avail: NTIS HC A03/MF A01 CSCL 01/1

The objective is to develop efficient numerical techniques for the study of aeroelastic response of a propfan in an unsteady transonic flow. A three dimensional unsteady Euler solver is being modified to address this problem. Author

N90-12501# Aeronautical Research Labs., Melbourne (Australia).
ADDITIONS AND CORRECTIONS TO SUPER: A PROGRAM FOR CALCULATING STEADY AND OSCILLATORY SUPERSONIC FLOW OVER A THIN WING, TAIL PLANE AND FIN
I. H. GRUNDY Apr. 1989 26 p
(AD-A211771; ARL-STRUC-TM-504; DODA-AR-005-591) Avail: NTIS HC A03/MF A01 CSCL 01/1

Changes are described for the computer program SUPER, which correct errors identified in the previous version of the program, and enable the calculation of generalized forces. Tables of generalized forces, calculated using SUPER and other programs, are presented for a standard AGARD configuration. GRA

N90-12503*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH IN NATURAL LAMINAR FLOW AND LAMINAR-FLOW CONTROL, PART 1
JERRY N. HEFNER, comp. and FRANCES E. SABO, comp. Dec. 1987 322 p Symposium held in Hampton, VA, 16-19 Mar. 1987
(NASA-CP-2487-PT-1; L-16350-PT-1; NAS 1.55:2487-PT-1)
Avail: NTIS HC A14/MF A02 CSCL 01/1

Since the mid 1970's, NASA, industry, and universities have worked together to conduct important research focused at developing laminar flow technology that could reduce fuel consumption for general aviation, commuter, and transport aircraft by as much as 40 to 50 percent. The symposium was planned in view of the recent accomplishments within the areas of laminar flow control and natural laminar flow, and the potential benefits of laminar flow technology to the civil and military aircraft communities in the United States. Included were technical sessions on advanced theory and design tool development; wind tunnel and flight research; transition measurement and detection techniques; low and high Reynolds number research; and subsonic and supersonic research.

N90-12504*# Boeing Commercial Airplane Co., Seattle, WA.
LAMINAR FLOW: CHALLENGE AND POTENTIAL
MARK E. KIRCHNER *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 25-44 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

Commercial air transportation has experienced revolutionary technology advances since WWII. These technology advances have resulted in an explosive growth in passenger traffic. Today, however, many technologies have matured, and maintaining a similar growth rate will be a challenge. A brief history of laminar flow technology and its application to subsonic and supersonic air transportation is presented. Author

N90-12505*# Douglas Aircraft Co., Inc., Long Beach, CA.
LFC: A MATURING CONCEPT
JOHN MORRIS *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 45-51 Dec. 1987
(DOUGLAS-PAPER-7878) Avail: NTIS HC A14/MF A02 CSCL 01/1

The existence of both turbulent and laminar flow was known for a long time, but it was not until the middle of the last century that the first systematic tests with fluids were conducted to establish the physical relationships and governing laws. The importance of turbulent and laminar airflows in aeronautics was recognized as early as the 1930's, but actual laminar flow control (LFC) investigations were not undertaken until the 1940's. This overview briefly touches on some of the historical development of LFC leading up to current activities. It then examines the technical problems being addressed and potential long-term LFC applications. Past and current Douglas activities are examined and the required future testing involving hybrid laminar flow control (HLFC) is discussed. Author

N90-12506*# Lockheed-Georgia Co., Marietta.
LOCKHEED LAMINAR-FLOW CONTROL SYSTEMS DEVELOPMENT AND APPLICATIONS
ROY H. LANGE *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 53-77 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

Progress is summarized from 1974 to the present in the practical application of laminar-flow control (LFC) to subsonic transport aircraft. Those efforts included preliminary design system studies of commercial and military transports and experimental investigations leading to the development of the leading-edge flight test article installed on the NASA JetStar flight test aircraft. The benefits of LFC on drag, fuel efficiency, lift-to-drag ratio, and operating costs are compared with those for turbulent flow aircraft. The current activities in the NASA Industry Laminar-Flow Enabling Technologies Development contract include summaries of activities in the Task 1 development of a slotted-surface structural concept using advanced aluminum materials and the Task 2 preliminary conceptual design study of global-range military hybrid laminar flow control (HLFC) to obtain data at high Reynolds numbers and at Mach numbers representative of long-range subsonic transport aircraft operation. Author

N90-12507*# Cessna Aircraft Co., Wichita, KS.
LAMINAR FLOW: THE CESSNA PERSPECTIVE
BRUCE E. PETERMAN *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 79-88 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

A review of Natural Laminar Flow (NLF) and Laminar-Flow Control activities over the last twenty years at the Cessna Aircraft Company is presented. Expected NLF benefits and remaining challenges are then described. Author

N90-12510*# Douglas Aircraft Co., Inc., Long Beach, CA.
THE RIGHT WING OF THE LEFT AIRPLANE
ARTHUR G. POWELL *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 141-161 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

The NASA Leading-Edge Flight Test (LEFT) program addressed the environmental issues which were potential problems in the application of Laminar Flow Control (LFC) to transport aircraft. These included contamination of the LFC surface due to dirt, rain, insect remains, snow, and ice, in the critical leading-edge region. Douglas Aircraft Company designed and built a test article which was mounted on the right wing of the C-140 JetStar aircraft. The test article featured a retractable leading-edge high-lift shield for contamination protection and suction through perforations on the upper surface for LFC. Following a period of developmental flight testing, the aircraft entered simulated airline service, which included exposure to airborne insects, heavy rain, snow, and icing conditions both in the air and on the ground. During the roughly 3 years of flight testing, the test article has consistently demonstrated laminar flow in cruising flight. The experience with the LEFT experiment was summarized with emphasis on significant test findings. The following items were discussed: test article design and features; suction distribution; instrumentation and transition point reckoning; problems and fixes; system performance and maintenance requirements. Author

N90-12516*# Arizona Univ., Tucson.
BOUNDARY-LAYER RECEPTIVITY AND LAMINAR-FLOW AIRFOIL DESIGN
EDWARD J. KERSCHEN *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 273-287 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

Boundary-layer receptivity examines the way in which external disturbances generate instability waves in boundary layers. Receptivity theory is complementary to stability theory, which studies the evolution of disturbances that are already present in the boundary layer. A transition prediction method which combines receptivity with linear stability theory would directly account for the influence of free-stream disturbances and also consider the characteristics of the boundary layer upstream of the neutral stability point. The current e sup N transition prediction methods require empirical correlations for the influence of environmental disturbances, and totally ignore the boundary layer characteristics upstream of the neutral stability point. The regions where boundary-layer receptivity occurs can be separated into two classes, one near the leading edges and the other at the downstream points where the boundary layer undergoes rapid streamwise adjustments. Analyses were developed for both types of regions, and parametric studies which examine the relative importance of different mechanisms were carried out. The work presented here has focused on the low Mach number case. Extensions to high subsonic and supersonic conditions are presently underway. Author

N90-12517*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GOERTLER INSTABILITY ON AN AIRFOIL
VIJAY KALBURGI, SIVA M. MANGALAM, J. RAY DAGENHART, and S. N. TIWARI (Old Dominion Univ., Norfolk, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 289-300 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/1

An effective computational scheme was developed to study the growth/damping of Goertler vortices along walls of variable curvature. Computational experiments indicate that when the amplification rates for the u-, v-, and w-perturbations are the same, the finite difference approach to solve the initial value problem and the normal mode approach give identical results for the Blasius boundary layer on constant curvature concave walls. The growth of Goertler vortices was rapid in the concave regions and was followed by sharp damping in the convex region. However, multiple sets of counter-rotating vortices were formed and remained far downstream in the convex region. The current computational scheme can be easily extended to more realistic problems including variable pressure gradients and suction effects. Author

N90-12519*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH IN NATURAL LAMINAR FLOW AND LAMINAR-FLOW CONTROL, PART 2
JERRY N. HEFNER, comp. and FRANCES E. SABO, comp. Dec. 1987 328 p Symposium held in Hampton, VA, 16-19 Mar. 1987
(NASA-CP-2487-PT-2; L-16350-PT-2; NAS 1.55:2487-PT-2)
Avail: NTIS HC A15/MF A02 CSCL 01/1

Part 2 of the Symposium proceedings includes papers addressing various topics in basic wind tunnel research/techniques and computational transitional research. Specific topics include: advanced measurement techniques; laminar flow control; Tollmien-Schlichting wave characteristics; boundary layer transition; flow visualization; wind tunnel tests; flight tests; boundary layer equations; swept wings; and skin friction.

N90-12523*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PREDICTED AND HOT-FILM MEASURED TOLLMIEN-SCHLICHTING WAVE CHARACTERISTICS
JOHN P. STACK, ROBERT B. YEATON, and J. RAY DAGENHART *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 377-380 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

The Tollmien-Schlichting (TS) instability is a time-dependence instability which can lead to transition of laminar boundary layers on airfoils. A comparison of theoretical predictions and experimental observations of the TS instability on the NLF(1)-0414F airfoil designed by Viken and Pfenninger. The theoretical predictions were obtained using the SALLY stability code. Test results, from the same hot films that were used to detect transition, revealed that TS waves could be detected by the hot films if the hot-film signal was adequately modified. Author

N90-12529*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL STUDIES ON GOERTLER VORTICES
SIVA M. MANGALAM (Analytical Services and Materials, Inc., Hampton, VA.), J. RAY DAGENHART, and JIM F. MEYERS *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 421-433 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

Goertler vortices arise in laminar boundary layers along concave walls due to an imbalance between pressure and centrifugal forces. In advanced laminar-flow control (LFC) supercritical airfoil designs, boundary-layer suction is primarily used to control Tollmien-Schlichting instability and cross-flow vortices in the concave region near the leading edge of the airfoil lower surface. The concave region itself is comprised of a number of linear segments positioned to limit the total growth of Goertler vortices. Such an approach is based on physical reasonings but rigorous theoretical justification or experimental evidence to support such an approach does not exist. An experimental project was initiated at NASA Langley to verify this concept. In the first phase of the project an experiment was conducted on an airfoil whose concave

region has a continuous curvature distribution. Some results of this experiment were previously reported and significant features are summarized. Author

N90-12530*# Lockheed-Georgia Co., Marietta.
AN EXPERIMENTAL EVALUATION OF SLOTS VERSUS POROUS STRIPS FOR LAMINAR-FLOW APPLICATIONS
KENNETH C. CORNELIUS *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 435-451 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

Detailed mean velocity and disturbance amplitude measurements were conducted in a Blasius boundary-layer flow with wall suction applied at three downstream locations. The main emphasis was a direct comparison of the growth rate of the instability wave with discrete spanwise slots versus wide porous strips. The results demonstrate that the local effects of suction through slots or very narrow porous strips have a greater beneficial effect on the stability of the boundary-layer flow relative to the suction influence of a wide porous strip. Codes which use continuous suction for the growth rates of the instability waves to determine the suction quantities for a multiple series of slots will be quite conservative in the estimation of the suction quantity. Guidelines were provided for suction-chamber design and flow rates to minimize internal oscillations which propagate into the boundary-layer flow. Author

N90-12531*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESULTS OF LFC EXPERIMENT ON SLOTTED SWEPT SUPERCRITICAL AIRFOIL IN LANGLEY'S 8-FOOT TRANSONIC PRESSURE TUNNEL
CUYLER W. BROOKS, JR. and CHARLES D. HARRIS *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 453-469 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

A large chord swept supercritical laminar-flow control (LFC) airfoil was designed, constructed, and tested in the Langley 8-foot Transonic Pressure Tunnel (TPT). The LFC airfoil experiment was established to provide basic information concerning the design and compatibility of high performance supercritical airfoils with suction boundary-layer control achieved through fine slots or porous surface concepts. Shockless pressure distribution was achieved. Full chord laminar flow was achieved on upper and lower surfaces. Full chord laminar flow was maintained at subcritical speeds and over large supercritical zones. Feasibility of combined suction laminarization and supercritical airfoil technology was demonstrated. B.G.

N90-12532*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BOUNDARY-LAYER STABILITY ANALYSIS OF LANGLEY RESEARCH CENTER 8-FOOT LFC EXPERIMENTAL DATA
SCOTT BERRY (Analytical Services and Materials, Inc., Hampton, VA.), J. RAY DAGENHART, CUYLER W. BROOKS, JR., and CHARLES D. HARRIS *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 471-489 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

An analytical study of linear-amplifying instabilities of a laminar boundary layer as found in the experimental data of the LaRC/8-foot laminar-flow control (LFC) experiment was completed and the results are presented. The LFC airfoil used for this experiment was a swept, supercritical design which removed suction air through spanwise slots. The amplification of small disturbances by linear processes on a swept surface such as this can be due to either Tollmien-Schlichting (TS) and/or crossflow (CF) mechanisms. This study consists of the examination of these two instabilities by both the commonly used incompressible (SALLY and MARIA) analysis and the more involved compressible (COSAL) analysis. A wide range of experimental test conditions with variations in Mach number, Reynolds number, and suction distributions were available for this study. Experimentally determined transition locations were found from thin-film techniques and were used to correlate the n-factors at transition for the range of test cases. Author

N90-12535*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THEORETICAL METHODS AND DESIGN STUDIES FOR NLF AND HLFC SWEPT WINGS AT SUBSONIC AND SUPERSONIC SPEEDS
SURESH H. GORADIA (Vigyan Research Associates, Inc., Hampton, VA.) and HARRY L. MORGAN, JR. *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 547-575 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

Laminarization of the boundary layer on the surface of aircraft wings can be accomplished by the use of concepts such as Natural Laminar Flow (NLF), Laminar-Flow Control (LFC), and Hybrid Laminar-Flow Control (HLFC). Several integral boundary-layer methods were developed for the prediction of laminar, transition, and separating turbulent boundary layers. These methods were developed for use at either subsonic or supersonic speeds, have small computer execution times, and are simple to use. The theoretical equations and assumptions which form the basis of the boundary-layer method, are briefly outlined and the results of several correlation cases with exciting experimental data are presented. B.G.

N90-12537*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF SOUND AND TEMPERATURE TO CONTROL BOUNDARY-LAYER TRANSITION
LUCIO MAESTRELLO, PARESH PARIKH, A. BAYLISS (Northwestern Univ., Evanston, IL.), L. S. HUANG, and T. D. BRYANT *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 593-616 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 01/1

The growth and decay of a wave packet convecting in a boundary layer over a concave-convex surface and its active control by localized surface heating are studied numerically using direct computations of the Navier-Stokes equations. The resulting sound radiations are computed using linearized Euler equations with the pressure from the Navier-Stokes solution as a time-dependent boundary condition. It is shown that on the concave portion the amplitude of the wave packet increases and its bandwidth broadens while on the convex portion some of the components in the packet are stabilized. The pressure field decays exponentially away from the surface and then algebraically, exhibiting a decay characteristic of acoustic waves in two dimensions. The far-field acoustic behavior exhibits a super-directivity type of behavior with a beaming downstream. Active control by surface heating is shown to reduce the growth of the wave packet but have little effect on acoustic far field behavior for the cases considered. Active control by sound emanating from the surface of an airfoil in the vicinity of the leading edge is experimentally investigated. The purpose is to control the separated region at high angles of attack. The results show that injection of sound at shedding frequency of the flow is effective in an increase of lift and reduction of drag. Author

N90-12539*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH IN NATURAL LAMINAR FLOW AND LAMINAR-FLOW CONTROL, PART 3
JERRY N. HEFNER, comp. and FRANCES E. SABO, comp. Dec. 1987 399 p Symposium held in Hampton, VA, 16-19 Mar. 1987
(NASA-CP-2487-PT-3; L-16350-PT-3; NAS 1.55:2487-PT-3)
Avail: NTIS HC A17/MF A03 CSCL 01/1

Part 3 of the Symposium proceedings contains papers addressing advanced airfoil development, flight research experiments, and supersonic transition/laminar flow control research. Specific topics include the design and testing of natural laminar flow (NLF) airfoils, NLF wing gloves, and NLF nacelles; laminar boundary-layer stability over fuselage forebodies; the design

of low noise supersonic/hypersonic wind tunnels; and boundary layer instability mechanisms on swept leading edges at supersonic speeds.

N90-12540*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN OF THE LOW-SPEED NLF(1)-0414F AND THE HIGH-SPEED HSNLF(1)-0213 AIRFOILS WITH HIGH-LIFT SYSTEMS
JEFFREY K. VIKEN, SALLY A. WATSON-VIKEN, WERNER PFENNINGER (Analytical Services and Materials, Inc., Hampton, VA.), HARRY L. MORGAN, JR., and RICHARD L. CAMPBELL *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 637-671 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

The design and testing of Natural Laminar Flow (NLF) airfoils is examined. The NLF airfoil was designed for low speed, having a low profile drag at high chord Reynolds numbers. The success of the low speed NLF airfoil sparked interest in a high speed NLF airfoil applied to a single engine business jet with an unswept wing. Work was also conducted on the two dimensional flap design. The airfoil was decambered by removing the aft loading, however, high design Mach numbers are possible by increasing the aft loading and reducing the camber overall on the airfoil. This approach would also allow for flatter acceleration regions which are more stabilizing for cross flow disturbances. Sweep could then be used to increase the design Mach number to a higher value also. There would be some degradation of high lift by decambering the airfoil overall, and this aspect would have to be considered in a final design. E.R.

N90-12541*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND TUNNEL RESULTS OF THE LOW-SPEED NLF(1)-0414F AIRFOIL
DANIEL G. MURRI, ROBERT J. MCGHEE, FRANK L. JORDAN, JR., PATRICK J. DAVIS, and JEFFREY K. VIKEN (Mandex, Inc., Falls Church, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 673-696 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

The large performance gains predicted for the Natural Laminar Flow (NLF)(1)-0414F airfoil were demonstrated in two-dimensional airfoil tests and in wind tunnel tests conducted with a full scale modified Cessna 210. The performance gains result from maintaining extensive areas of natural laminar flow, and were verified by flight tests conducted with the modified Cessna. The lift, stability, and control characteristics of the Cessna were found to be essentially unchanged when boundary layer transition was fixed near the wing leading edge. These characteristics are very desirable from a safety and certification view where premature boundary layer transition (due to insect contamination, etc.) must be considered. The leading edge modifications were found to enhance the roll damping of the Cessna at the stall, and were therefore considered effective in improving the stall/departure resistance. Also, the modifications were found to be responsible for only minor performance penalties. Author

N90-12542*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND TUNNEL RESULTS OF THE HIGH-SPEED NLF(1)-0213 AIRFOIL
WILLIAM G. SEWALL, ROBERT J. MCGHEE, DAVID E. HAHNE, and FRANK L. JORDAN, JR. *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 697-726 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

Wind tunnel tests were conducted to evaluate a natural laminar flow airfoil designed for the high speed jet aircraft in general aviation. The airfoil, designated as the High Speed Natural Laminar Flow (HSNLF)(1)-0213, was tested in two dimensional wind tunnels to investigate the performance of the basic airfoil shape. A three dimensional wing designed with this airfoil and a high lift flap system is also being evaluated with a full size, half span model. Author

N90-12543*# Boeing Military Airplane Development, Seattle, WA.
DESIGN AND TEST OF A NATURAL LAMINAR FLOW/LARGE REYNOLDS NUMBER AIRFOIL WITH A HIGH DESIGN CRUISE LIFT COEFFICIENT
C. E. KOLESAR *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 727-751 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

Research activity on an airfoil designed for a large airplane capable of very long endurance times at a low Mach number of 0.22 is examined. Airplane mission objectives and design optimization resulted in requirements for a very high design lift coefficient and a large amount of laminar flow at high Reynolds number to increase the lift/drag ratio and reduce the loiter lift coefficient. Natural laminar flow was selected instead of distributed mechanical suction for the measurement technique. A design lift coefficient of 1.5 was identified as the highest which could be achieved with a large extent of laminar flow. A single element airfoil was designed using an inverse boundary layer solution and inverse airfoil design computer codes to create an airfoil section that would achieve performance goals. The design process and results, including airfoil shape, pressure distributions, and aerodynamic characteristics are presented. A two dimensional wind tunnel model was constructed and tested in a NASA Low Turbulence Pressure Tunnel which enabled testing at full scale design Reynolds number. A comparison is made between theoretical and measured results to establish accuracy and quality of the airfoil design technique. Author

N90-12549*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AND NUMERICAL ANALYSES OF LAMINAR BOUNDARY-LAYER FLOW STABILITY OVER AN AIRCRAFT FUSELAGE FOREBODY
PAUL M. H. W. VIJGEN (Kansas Univ., Lawrence.) and BRUCE J. HOLMES *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 861-886 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

Fuelled by a need to reduce viscous drag of airframes, significant advances have been made in the last decade to design lifting surface geometries with considerable amounts of laminar flow. In contrast to the present understanding of practical limits for natural laminar flow over lifting surfaces, limited experimental results are available examining applicability of natural laminar flow over axisymmetric and nonaxisymmetric fuselage shapes at relevantly high length Reynolds numbers. The drag benefits attainable by realizing laminar flow over nonlifting aircraft components such as fuselages and nacelles are shown. A flight experiment to investigate transition location and transition mode over the forward fuselage of a light twin engine propeller driven airplane is examined. Author

N90-12554*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC LAMINAR-FLOW CONTROL
DENNIS M. BUSHNELL and MUJEEB R. MALIK (High Technology Corp., Hampton, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 923-946 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

Detailed, up to date systems studies of the application of laminar flow control (LFC) to various supersonic missions and/or vehicles, both civilian and military, are not yet available. However, various first order looks at the benefits are summarized. The bottom line is that laminar flow control may allow development of a viable second generation SST. This follows from a combination of reduced fuel, structure, and insulation weight permitting operation at higher altitudes, thereby lowering sonic boom along with improving performance. The long stage lengths associated with the emerging economic importance of the Pacific Basin are creating a serious and renewed requirement for such a vehicle. Supersonic LFC techniques are discussed. Author

N90-12556*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECTS OF WALL SURFACE DEFECTS ON BOUNDARY-LAYER TRANSITION IN QUIET AND NOISY SUPERSONIC FLOW
E. LEON MORRISETTE and THEODORE R. CREEL, JR. *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 965-980 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

The design of supersonic vehicles with laminar flow control and vehicles such as the Space Shuttle requires information on allowable transition tolerances to fabrication defects such as discrete surface roughness and waviness. A relatively large data base on the effects of discrete roughness on transition exists for subsonic and supersonic speeds. The existing supersonic wind tunnel transition data are contaminated by wind tunnel noise emanating from the turbulent boundary layers on the nozzle walls. Roughness and waviness transition data obtained in a quiet Mach 3.5 supersonic wind tunnel are compared with those obtained in conventional noisy flows. Author

N90-12557*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF BOUNDARY-LAYER INSTABILITY MECHANISMS ON A SWEPT LEADING EDGE AT MACH 3.5
THEODORE R. CREEL, JR., MUJEEB R. MALIK (High Technology Corp., Hampton, VA.), and IVAN E. BECKWITH *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 981-995 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

A brief outline of the experimental and theoretical investigation of boundary layer instability mechanisms on a swept leading edge at Mach 3.5 is presented. Transition is affected by wind tunnel noise only when roughness is present. Local bar-R sub * Reynolds number and k/eta sub * are useful correlation parameters for a wide range of free stream Mach numbers. Stability theory is in good agreement with the experimental cross flow vortex wavelength. These conclusions are briefly discussed. Author

N90-12558*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC BOUNDARY-LAYER TRANSITION ON THE LARC F-106 AND THE DFRF F-15 AIRCRAFT. PART 1: TRANSITION MEASUREMENTS AND STABILITY ANALYSIS
FAYETTE S. COLLIER, JR., JOSEPH B. JOHNSON, OLLIE J. ROSE (PRC Kentron, Inc., Hampton, VA.), and D. S. MILLER *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 997-1014 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

For the case of the F-15 flight tests, boundary layer transition was observed up to Mach numbers of 1.2. For very limited and specific flight conditions, laminar flow existed back to about 20 percent chord on the surface clean up glove. Hot film instrumentation was effective for locating the region of transition. For the F-106 flight tests, transition on the wing or vertical tail generally occurred very near the attachment line. Transition was believed to be caused by either attachment line contamination or strong cross flow development due to the high sweep angles of the test articles. The compressibility analysis showed that cross flow N-factors were in the range of 5 to 12 at transition. Author

N90-12559*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC BOUNDARY-LAYER TRANSITION ON THE LARC F-106 AND THE DFRF F-15 AIRCRAFT. PART 2: AERODYNAMIC PREDICTIONS
OLLIE J. ROSE (PRC Kentron, Inc., Hampton, VA.) and D. S. MILLER *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 1015-1024 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/1

In the leading edge region, the measured pressure distributions exhibit extreme variations from strong suction peaks to a pressure maximum at the attachment line. These variations occur over short distances on the wing surface, and their character changes with changes in Mach number and angle of attack. The data/theory comparisons show that the character of the measured pressure distributions is well predicted for every Mach number and/or angle of attack condition considered. There is good agreement between theory and experiment for the location of the attachment line and suction peaks. The pressure magnitudes are well represented in the critical leading edge region, including the pressure maximum on the attachment line. The wing/body/inlet results agree well with the wing alone back to about 20 percent of chord where the upper surface suction peak typically occurs. The largest differences between theory and measurement always occur in the vicinity of suction peaks, with the difference being approximately 15 percent or less. In regions of largest error, the predicted pressures underestimate the suction peak strength for each case considered. The ability of the NCOREL code to reproduce wing pressure characteristics is shown. Author

N90-12560*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF UNSTEADY BLADE SURFACE PRESSURES ON AN ADVANCED PROPELLER AT AN ANGLE OF ATTACK
M. NALLASAMY (Sverdrup Technology, Inc., Cleveland, OH.) and J. F. GROENEWEG Nov. 1989 28 p Presented at the 12th Aeroacoustics Conference, San Antonio, TX, 10-12 Apr. 1989; sponsored by AIAA Previously announced in IAA as A89-40473
(Contract NAS3-25266)
(NASA-TM-102374; E-5108; NAS 1.15:102374; AIAA-89-1060)
Avail: NTIS HC A03/MF A01 CSCL 01/1

The numerical solution of the unsteady, three-dimensional, Euler equations is considered in order to obtain the blade surface pressures of an advanced propeller at an angle of attack. The specific configuration considered is the SR7L propeller at cruise conditions with a 4.6 deg inflow angle corresponding to the plus 2 deg nacelle tilt of the Propeller Test Assessment (PTA) flight test condition. The results indicate nearly sinusoidal response of the blade loading, with angle of attack. For the first time, detailed variations of the chordwise loading as a function of azimuthal angle are presented. It is observed that the blade is lightly loaded for part of the revolution and shocks appear from hub to about 80 percent radial station for the highly loaded portion of the revolution. Author

N90-12561*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SOME OBSERVATIONS ON TRANSITORY STALL IN CONICAL DIFFUSERS
K. B. M. Q. ZAMAN and M. D. DAHL 1989 13 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA
(NASA-TM-102387; E-5128; NAS 1.15:102387; AIAA-90-0048)
Avail: NTIS HC A03/MF A01 CSCL 01/1

Results from an experimental investigation on the flow through conical diffusers are presented. The mean and fluctuating velocity fields are compared for three diffusers with total diffusion angles of 16, 20 and 24 degrees, in the throat Mach number (M sub t) range of 0.05 to 0.95. Each of the diffusers were 14 cm long and had a 5.08 cm inlet diameter, and the flow exited into the ambient. The boundary layer at the throat was thin with the throat diameter (D sub t) to momentum thickness (O) ratio being as high as 800 at M(sub t) = 0.4. While the 16 deg diffuser flow exited with a top-hat mean velocity profile, increasing losses due to increasing separation resulted in fuller profiles for the 20 and 24 degree cases. A detailed flow field study was conducted for the 16 deg. diffuser. The u'-spectrum, measured at the exit plane, exhibited a peak apparently due to the ensuing jet column instability throughout the M(sub t) range covered. In addition, a much lower frequency spectral peak also occurred in the M(sub t) range of 0.3 to 0.7. Both of the spectral peaks were due to axisymmetric flow fluctuations. A self-sustaining flow oscillation occurred in the M(sub t) range of 0.6 to 0.85, emitting a loud tone, when the jet column instability frequency matched the resonance frequency of the

diffuser. Limited data showed that artificial acoustic excitation was effective in reducing the flow fluctuations, with a resultant increase in the pressure recovery, at low M(sub t). Author

N90-12562# Royal Aerospace Establishment, Farnborough (England).
IMPROVEMENTS IN THE FORMULATIONS AND NUMERICAL SOLUTION OF THE EULER PROBLEM FOR SWEPT WINGS
M. F. PAISLEY and M. G. HALL 17 Aug. 1988 14 p Presented at the IUTAM Symposium Transsonicum 3, Goettingen, Fed. Republic of Germany, 24-27 May 1988
(RAE-TM-AERO-2139; BR108362; ETN-89-94829) Copyright
Avail: NTIS HC A03/MF A01

A method to calculate steady inviscid transonic flow for swept wings is described. It is based on a multigrid cell vertex finite volume Euler method. The effect of velocity perturbations generated from Klunker's analytic asymptotic solution to the transonic small disturbance equation, is applied. The geometry of the wing tip is modeled with three successively finer C-O grids. The results show marked differences in comparison with those obtained on C-H grids. The results indicate that a shock wave mechanism can contribute to the generation of tip vortices in compressible inviscid flow. For reliable prediction of wing performance the importance in good modeling of both the wing tip geometry and the flow around the tip is shown. ESA

N90-12563# Royal Aerospace Establishment, Farnborough (England).
CFD METHODS FOR DRAG PREDICTION AND ANALYSIS CURRENTLY IN USE IN UK
P. R. ASHILL 14 Oct. 1988 22 p
(RAE-TM-AERO-2146; BR109770; ETN-89-95001) Copyright
Avail: NTIS HC A03/MF A01

The computational method developed in UK for the prediction of the drag of aircraft components at subsonic and supersonic speeds in the field of Computational Fluid Dynamics (CFD), are reviewed. The flow modeling is analyzed. The methods have a useful function both in the early stages of aircraft design, and later in support of windtunnel test as a diagnostic tool, and also to extrapolate the data to full scale. ESA

N90-12564# Institut Franco-Allemand de Recherches, Saint-Louis (France).
VOLUMETRIC ANALYSIS BY SPONTANEOUS RAMAN DIFFUSION IN A SUPERSONIC WIND TUNNEL [MESURE DE LA MASSE VOLUMIQUE MOYENNE LOCALE PAR DIFFUSION RAMAN SPONTANEE DANS UNE SOUFFLERIE SUPERSONIQUE]
L. BOBIN and G. BROM 27 Apr. 1988 17 p In FRENCH Original contains color illustrations
(Contract DRET-87-068)
(ISL-R-109/88; ETN-89-95028) Avail: NTIS HC A03/MF A01

Measurements of average local volumetric mass using laser Raman techniques in a supersonic wind tunnel are described. Although the set-up needs improvement, the technique is concluded to be useable. Impact of the laser beam on any object in motion should be avoided. The measuring point should be far from the impact area of the beam. The precision of measurement can be improved by significantly increasing the integration period. Photographs of the experimental apparatus and preliminary results are provided. ESA

N90-12566# Aeronautical Research Labs., Melbourne (Australia).
DEVELOPMENT OF A VSAERO (VORTEX SEPARATION AERODYNAMICS) MODEL OF THE F/A-18
R. TOFFOLETTO Mar. 1989 29 p
(AD-A212442; ARL-FLIGHT-MECH-TM-404; DODA-AR-005-543)
Avail: NTIS HC A03/MF A01 CSCL 01/1

Vortex Separation AERODynamics (VSAERO) was used to produce an aerodynamic model of the aircraft. When fully developed, results from the model will be compared with results obtained from experiments planned to be carried out in the ARL wind tunnel. The velocity field and wake geometry in the vicinity of the aircraft, and the pressure distribution on the aircraft were calculated for various flight conditions. Calculated lift coefficients for the whole aircraft were compared with wind tunnel results obtained from McDonnell Aircraft company. The model was also used to study the effect of engine intake velocity on the aerodynamics of the aircraft. The major problem encountered during the development of the model was a numerical instability caused by the complicated vortex/vortex and vortex/body interactions in the vicinity of the tail of the aircraft. During this time, a new version of VSAERO was installed at ARL which promised greater stability in this area. It also allowed for a denser grid in the wake structure. Comparisons were made between the old and new versions to determine the extent of the improvements. GRA

N90-12568# Defence Research Establishment Atlantic, Dartmouth (Nova Scotia).
CHORDWISE LOADING AND CAMBER FOR TWO-DIMENSIONAL THIN SECTIONS
MICHAEL MACKAY Aug. 1989 20 p
(AD-A213318; DREA-TM-89/219) Avail: NTIS HC A03/MF A01 CSCL 01/1

Derivations are given for the calculation of section camberline from a given segmented chordwise load distribution, and for the inverse problem. In both cases, the algorithms are exact within the limits of thin wing theory. Two dimensional, thin, lifting sections were studied and the derivation is given of the camberline from a segmented chordwise loading (the design problem) and the calculation of loading from a discretely-defined camberline (the analysis problem). To the author's knowledge, these derivations have not been published for the general case, although the results for some specific cases are well known, good examples are the NACA a-series camberlines, obtained from simple two-segment load distributions, which have been widely used for many years. GRA

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A90-14367* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT AND GROUND VEHICLE FRICTION MEASUREMENTS OBTAINED UNDER WINTER RUNWAY CONDITIONS
THOMAS J. YAGER (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 7 p. refs
(SAE PAPER 891070) Copyright

Tests with specially instrumented NASA B-737 and B-727 aircraft together with several different ground friction measuring devices have been conducted for a variety of runway surface types and wetness conditions. This effort is part of the Joint FAA/NASA Aircraft/Ground Vehicle Runway Friction Program aimed at obtaining a better understanding of aircraft ground handling performance under adverse weather conditions, and defining relationships between aircraft and ground vehicle tire friction measurements. Aircraft braking performance on dry, wet, snow-, and ice-covered runway conditions is discussed together with ground vehicle friction data obtained under similar runway conditions. For the wet, compacted snow- and ice-covered runway conditions, the relationship between ground vehicles and aircraft friction data is identified. The influence of major test parameters on friction measurements such as speed, test tire characteristics, and surface contaminant-type are discussed. The test results indicate that use of properly maintained and calibrated ground

vehicles for monitoring runway friction conditions should be encouraged particularly under adverse weather conditions.
Author

A90-15876#
THE FAA TECHNICAL CLASSIFICATION OF AIRCRAFT AND AIRPORTS [KLASYFIKACJA TECHNICZNA SAMOLOTOW I LOTNISK WG FAA]
ANTONI SWIATECKI (Warszawa, Politechnika, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 44, March 1989, p. 19-21. In Polish.

N90-11715# Naval Postgraduate School, Monterey, CA. Dept. of Computer Science.
POST CRASH FLIGHT ANALYSIS: VISUALIZING FLIGHT RECORDER DATA M.S. Thesis
MARK JAY CHRISTIAN Jun. 1989 97 p
(AD-A212063) Avail: NTIS HC A05/MF A01 CSCL 01/2

Previous research has produced a real-time, three dimensional, interactive moving platform simulator (MPS). The simulator utilizes Defense Mapping Agency digital terrain elevation data to generate the three dimensional terrain and runs on Silicon Graphics, Inc. IRIS 4D/70GT graphics workstations. The MPS system was used as a basis for a variety of military applications. The modifications of the MPS system for use as a crash investigation tool for the U.S. Army aircraft mishaps are presented. Flight recorder data from the mishap aircraft is used to graphically reconstruct the flight of the aircraft. Flight attitudes, gauge readings, switch positions, warning and advisory light indicators, and flight control inputs are displayed. The visualization of the flight recorder data greatly aids in the analysis of the causes of an aircraft mishap.
GRA

N90-11716# Limoges Univ. (France). Inst. de Recherches en Communications Optiques et Microondes.
NUMERICAL SIMULATION OF AEROPLANE RESPONSE TO A LIGHTNING INJECTION Final Report [SIMULATION NUMERIQUE DE LA REPONSE D'UN AVION A UNE INJECTION DE LA FOUDRE]
B. JECKO and A. ROUSSAUD 1989 146 p In FRENCH
(Contract DRET-87/1497/DS/SR2)
(ETN-89-95271) Avail: NTIS HC A07/MF A01

Aeroplane response to the electromagnetic impulsions of lightning is investigated. The process is analyzed as a diffraction of the electromagnetic waves by wirelike structures. This model is applied to the lightning channel formation. The resonance in the cylinder (representative of the airplane and the lightning injection model coupling) is demonstrated. The development of positive and negative beam leads during lightning are modeled. It is shown that the current impulsions generated in the airborne electronic equipment during lightning, must be taken into account in signal transmissions.
ESA

N90-11717 Civil Aviation Authority, London (England).
UK AIRMISSES INVOLVING COMMERCIAL AIR TRANSPORT, MAY-AUGUST 1988
May 1989 87 p
(ISSN-0951-6301; ETN-89-95249) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom, 5 sterling pounds

Statistics regarding the number of airmisses in Great Britain over the period from 1978 to 1988 are provided. Detailed accounts of airmisses that occurred between May and August 1988 are given. A summary of the working groups discussion concerning each airmiss reported during this period is provided. The procedure by which airmisses are processed is outlined.
ESA

N90-11718 Civil Aviation Authority, London (England).
UK AIRMISSES INVOLVING COMMERCIAL AIR TRANSPORT
Aug. 1988 53 p
(CAA-2/88; ISSN-0951-6301; ETN-89-95533) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom, 5 sterling pounds

The commercial airmiss reports for the period from Sep. - Dec. 1987 are listed. The procedures involved in reporting, investigating and categorizing air misses are summarized. Full transcripts of the airmiss report data for the study period are provided. These include a summary of the working group's discussions and an assessment of risk and cause for each airmiss cited.
ESA

N90-11719 Civil Aviation Authority, London (England).
AIRCRAFT CABIN FIRE SUPPRESSION BY MEANS OF AN INTERIOR WATER SPRAY SYSTEM
R. T. WHITFIELD, Q. DAWHITFIELD, and J. STEEL Jul. 1988 69 p Original contains color illustrations
(CAA-PAPER-88014; ETN-89-95535) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom, 10 sterling pounds

Tests carried out using a fully furnished Trident aircraft to determine the effectiveness of an interior water spray system in preserving a survivable cabin environment in the face of an external fuel fire are described. The water spray system should delay penetration of an external fire, minimize the combustion of cabin furnishings, prevent the buildup of unsurvivable temperatures within the cabin, and delay the transfer of combustion products, including toxic gases into the occupied areas of the cabin. In three tests, during which the aircraft structure suffered increasing external damage, the water spray prevented fire damage in the cabin and delayed the migration of toxic fumes.
ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A90-13979#
INTERNATIONAL SATELLITE RADIONAVIGATION AND RADIOLOCATION - CHOOSING AMONG THE OPTIONS
G. V. KINAL (International Maritime Satellite Organization, London, England) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 101, 103-106. refs

The current status of planning for GPS-based civilian communication, navigation, and surveillance (CNS) networks is reviewed from the perspective of the Inmarsat organization. The need for civilian satellite GPSs despite the coverage of the military systems Navstar and Glonas is pointed out, and particular attention is given to the proposed ESA Navsat system. The originally proposed configuration of 24 GEO satellites in three inclined 12-h circular orbits is compared with an alternative configuration of 6 GEO satellites and 12 satellites in inclined Molniya highly elliptic 12-h orbits, and the possibility of progressive implementation in the latter configuration is discussed. Also considered are the Rexstar proposal for a regional CNS, the German GRANAS proposal, and tests of the Navsat PRN ranging-signal format. Diagrams and maps are provided.
T.K.

A90-13980#
KINEMATIC AND PSEUDO-KINEMATIC GPS
BENJAMIN W. REMONDI (Ashtech, Inc., Sunnyvale, CA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 115-121. refs

The theoretical bases of satellite-based GPSs are examined in an analytical review. The evolution of kinematic GPS surveying and navigation is recalled; the features of specific static, kinematic, and pseudokinematic (PK) techniques are defined; the governing equations for carrier-phase techniques are derived; the procedures for antenna-exchange and PK methods are explained; and the strengths and weaknesses of the methods are discussed. The

special capabilities of PK methods are demonstrated with a numerical example involving an airport survey. It is concluded that PK methods are already fully feasible and superior to static methods, while kinematic methods such as antenna exchange offer the greatest potential for high-speed accurate measurements in scientific and engineering applications. T.K.

A90-13982#
A TEST OF AIRBORNE KINEMATIC GPS POSITIONING FOR AERIAL PHOTOGRAPHY - METHODOLOGY
G. KEEL, H. JONES, and G. LACHAPELLE (Nortech Surveys /Canada/, Inc., Calgary) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 147-151. refs

The feasibility of using satellite GPSs for real-time three-dimensional aircraft positioning during photogrammetric surveys was investigated experimentally. The main test equipment comprised: (1) a twin-engine aircraft with a GPS receiver operating in differential mode with a 15-Hz bandwidth, a photogrammetric camera, and a computer-addressable precision timing system (CAPTS) to time the shutter openings; and (2) a ground monitor station with GPS receiver in 8-Hz-bandwidth mode and a CAPTS to permit calibration of the time delay between GPS time and exposure time. Postflight data reduction was performed using a modified version of the HYDROSTAR package (Lachapelle et al., 1988); the results are presented in tables and discussed in detail. The errors in the GPS positions were found to be less than 1 m in all three coordinates, demonstrating the suitability of GPS for cost-effective real-time application. T.K.

A90-13983#
A TEST OF KINEMATIC GPS COMBINED WITH AERIAL PHOTOGRAPHY - ORGANIZATION, LOGISTICS AND RESULTS
RICHARD MOREAU (Ministere de l'Energie et des Ressources, Sainte-Foy, Canada) and MICHEL PERRON (Hauts-Monts, Inc., Beauport, Canada) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 153-158. refs

Results are reported from experimental trials conducted in Quebec to assess the feasibility of using satellite GPSs for real-time three-dimensional aircraft positioning during photogrammetric surveys, as described by Keel et al. (1989). A twin-engine aircraft equipped with a differential-mode GPS receiver, a photogrammetric camera, and a precision timing system flew within 20 km of a ground monitor station with a GPS receiver and an identical timing system. The organization of the test and details of the postflight data reduction are discussed, and the results are presented in tables. It is shown that the GPS position errors were less than 1 m in all three coordinates, demonstrating the ability of kinematic GPS to eliminate the need for ground control during 1:20,000 mapping operations. T.K.

A90-13984#
AVIONIC SYSTEM BASED ON GLOBAL NAVIGATIONAL SATELLITE SYSTEM
S. FRED SINGER (DOT, Washington, DC) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 175, 176.

The design concept of an avionics package integrating five different satellite-GPS-based functions is briefly outlined. The basic advantages of a fully operational Navstar GPS are reviewed, including global coverage, three-dimensional position and velocity measurement, and accuracy, and it is suggested that an integrated GPS avionics package could provide enhanced performance and high reliability, with significant savings in hardware cost and weight. The GPS functions described are (1) navigation, (2) automatic dependent surveillance en route and near airports, (3) TCAS, (4) precision landings (using a differential-GPS landing system), and (5) in situ windshear detection and escape guidance. T.K.

A90-13985#
AUTOLANDING WITH GPS
B. W. PARKINSON and K. T. FITZGIBBON (Stanford University, CA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 177-185. refs

The feasibility of a GPS-based automatic landing system (ALS) is investigated by means of numerical simulations. The FAA landing requirements are reviewed; the velocity-sensing capabilities of Navstar-GPS are summarized; a GPS error model is constructed from test measurements on a 5-channel receiver; the principles of differential GPS (DGPS) operation are explained; and particular attention is given to the design concept of a GPS-based onboard ALS. Results from simulations of glide-slope and flare phases with conventional GPS or DGPS, integral-control-law (ICL) or LQG regulators, and windless or windy conditions are presented in tables and graphs and discussed in detail. It is found that conventional GPS with the current satellite configuration is adequate only for nonprecision landings, whereas DGPS with one pseudolite could satisfy FAA category II and DGPS with two pseudolites could satisfy category III. The ICL controller provides better performance than the LQG controller under windy conditions. T.K.

A90-13989#
GPS: ARRIVAL IN THE FLEET - A GPS AN/SRN-25 RECEIVER ASSESSMENT
PETER J. KARCZ (Vitro Corp., Arlington, VA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 221-225.

Results are reported from performance tests on the AN/SRN-25 (V), an integrated Transit/Omega receiver with Navstar-GPS capability being used by the U.S. Navy. The operational requirements for the receiver are reviewed, and typical fleet GPS utilizations are described. The system static and dynamic testing program demonstrated that the AN/SRN-25 (V) met all Navy specifications, and interviews with personnel indicate that it is considered a valuable, user-friendly real-time navigation aid. Position accuracy of 17 m or better and average availability of about 12 h/day are reported. T.K.

A90-13990#
INTEGRATION OF GPS WITH THE CARRIER AIRCRAFT INERTIAL NAVIGATION SYSTEM (CAINS)
WILLIAM A. CHITTICK (U.S. Navy, Naval Avionics Center, Indianapolis, IN) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 227-235.

The Carrier Aircraft Inertial Navigation System (CAINS) AN/ASN-130A is the U.S. Navy standard INS used in the F/A-18, AV-8B, and EA-6B aircraft. Data exchange between between the GPS receiver and INS is accomplished with each acting as a remote terminal on an MIL-STD-1553 bus. The operational flight program of CAINS was modified to use the GPS background navigation output, in the closed-loop (feedback) mechanization. CAINS uses GPS reference data to perform both in-flight alignment on a moving platform (shipboard or airborne) and hybrid navigation. Test results are included which show the INS calibration benefits of he closed-loop mechanization and the resulting INS performance during GPS outages. Author

A90-13992#
OPTIMAL SELECTION OF GPS SETS TO MINIMIZE EMITTER LOCATION ERRORS
STEPHEN G. PETERS and ZDZISLAW H. LEWANTOWICZ (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 243-252. refs

The GPS selection for a set of three aircraft used to locate a ground-based electromagnetic energy emitter is examined. The impact of both satellite and collector relative positions on emitter

location errors is examined. An algorithm which selects the optimum satellite configuration for minimum emitter location errors is developed. It is found that the performance of three satellites is nearly as good as that obtained using four satellites since only three satellites are necessary to determine the emitter horizontal position and user clock bias. K.K.

A90-13994#
FLIGHT DEMONSTRATION OF TWO AND THREE SATELLITE NAVIGATION
RONALD B. DAYTON, JOHN T. NIELSON, and RICHARD F. NOLTING (Boeing Aerospace, Seattle, WA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 259-266.

A modification of a GPS receiver/processor unit designed for operation in an under-determined state with two or three satellites has been evaluated. It is found that the use of an atomic clock of sufficient stability and a radar altimeter of sufficient accuracy with the modified receiver can effectively increase the GPS operating time by continuing to track down to two satellites following operation with four or three satellites. The feasibility and utility of a combination of a cesium clock and a radar altimeter have been demonstrated in a flight test. The test system, test conditions, and the results obtained are discussed. V.L.

A90-13997#
INTEGRATED NAVIGATION SYSTEM DESIGN AND PERFORMANCE WITH PHASE III GPS USER EQUIPMENT
P. SINHA, K. BARCKLEY, and D. DEDOES IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 283-300. refs

The paper presents two ways of utilizing GPS position, velocity, and time data to maintain the system navigation solution. These include periodic reinitialization of the Inertial Navigation System solution to the GPS and measurements to a navigation filter resident in the mission computer. Pertinent closed loop design issues are discussed and the performance of both the user equipment and the system navigation solutions is demonstrated. K.K.

A90-14001#
ACCURACY CONSIDERATIONS FOR GPS TSPI SYSTEM DESIGN
CARL HOEFENER and ROBERT J. VAN WECHEL (Interstate Electronics Corp., Anaheim, CA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 329-332. refs

GPS has become popular as a time and space-position information (TSPI) source on tracking ranges because it offers a potentially more accurate and more versatile tracking technique than radar. As GPS tends to be a complex navigation system, there are many potential error sources that must be considered. When using GPS for a range instrumentation tool, many of the potential error sources can be eliminated or minimized because it is being used in a confined preestablished area, and it can be utilized at selected predetermined times. All these factors can help in optimizing the accuracies obtained from a GPS system when utilized for TSPI on the ranges. Each of the major GPS error sources is defined, and proposed methods of compensation are discussed. Expected accuracies for typical system configurations are presented. Author

A90-14013#
LORAN-AIDED GPS INTEGRITY
R. GROVER BROWN and PAUL W. MCBURNEY (Iowa State University of Science and Technology, Ames) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 461-466. Research sponsored by Iowa State University of Science and Technology. refs

One-way ranging on Loran-C stations is suggested as another way of bringing in additional measurement information. Gaps in GPS Receiver Autonomous Integrity Monitoring (RAIM) availability are described, and solutions to these gaps are discussed. Simulation results of this Loran-aided GPS integrity concept are reported. C.D.

A90-14357
MODE S TRANSPONDERS - A NEW AVIONICS PRODUCT
JOHN E. BROWN (Bendix/King, Olathe, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 13 p.
(SAE PAPER 891055) Copyright

The FAA's plan for modernization of the National Airspace System entails the adoption of Mode S transponders that are compatible with the new Air Traffic Control Radar Beacon System (ATCRBS); Mode S units will possess all the features of Mode A and Mode C ATCRBS transponders, while also incorporating an additional receiver, a switching duplexer, DPSK demodulation, and digital circuits to handle Mode S processing requirements. The Mode S data link will allow transmissions of ATC and air-to-air data exchanges for collision avoidance; such additional flight advisory services as weather reports and Automatic Terminal Information System broadcasts can be furnished to a cockpit display via this data link. O.C.

A90-14732*# *Rice Univ., Houston, TX.*
PENETRATION LANDING GUIDANCE TRAJECTORIES IN THE PRESENCE OF WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 806-814. Research supported by the Boeing Commercial Airplane Co. and Air Line Pilots Association. Previously cited in issue 21, p. 3485, Accession no. A88-50179. refs
(Contract NAG1-516)
Copyright

A90-14733*# Rice Univ., Houston, TX.
ACCELERATION, GAMMA, AND THETA GUIDANCE FOR ABORT LANDING IN A WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA), and R. L. BOWLES (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 815-821. Research supported by the Boeing Commercial Airplane Co., and Air Line Pilots Association. refs
(Contract NAG1-516)
Copyright

This paper is concerned with the guidance of abort landing trajectories in a windshear. First, optimal trajectories are determined by minimizing the peak value of the altitude drop. Then, two guidance schemes, approximating the optimal trajectors, are developed: acceleration guidance (based on the relative acceleration) and gamma guidance (based on the absolute path inclination). From numerical experiments, it appears that both the acceleration guidance and the gamma guidance yield trajectories that are close to the optimal trajectory. In addition, a theta guidance scheme (modified constant pitch guidance) is developed that is superior to the constant pitch guidance in terms of the altitude loss and the survival capability in severe windshears. Author

A90-15315
GPS MONITOR ALARM LIMITS FOR NONPRECISION APPROACHES
ROBERT LOH (Mitre Corp., McLean, VA) Navigation (ISSN 0028-1522), vol. 36, Fall 1989, p. 253-263. refs
Copyright

The future navigation accuracy requirement for nonprecision approaches has been estimated to be 100 m. GPS can satisfy this requirement by limiting the 95 percent horizontal position determination accuracy for civil users to 100 m. The FAA is investigating GPS signal integrity monitoring and the associated monitor alarm limits in order to satisfy the integrity response time

requirements for nonprecision approaches. This paper documents a rationale for the 100 m GPS horizontal accuracy requirement and evaluates the impact of using GPS monitor alarm limits greater than 100 m. The GPS monitor alarm limit must be set above 100 m in order to reduce the number of potential alarms. The significant impact on nonprecision approaches, as defined in the Terminal Instrument Procedures, appears to be the size of the obstacle clearance areas and their effect on the minimum descent altitude. Author

N90-11722# Royal Signals and Radar Establishment, Malvern (England).
A SIMULATION STUDY OF LANDING TIME ALLOCATION PROCEDURES FOR USE IN COMPUTER-ASSISTED AIR TRAFFIC MANAGEMENT SYSTEMS
A. J. BUDD 28 Apr. 1989 13 p
(AD-A212159; RSRE-MEMO-4132; DRIC-BR-110739) Avail: NTIS HC A03/MF A01 CSCL 01/5

During busy periods at major airports, inbound aircraft have to queue for use of the landing runway. In future air traffic systems it is likely that controllers will be able to make use of computer-proposed landing sequences and speed control advice. One proposed method for allocating aircraft landing times in such systems is the Time Horizon method. According to this method, a preferred landing time is calculated for each aircraft some way out from the airport, and a planned landing time is allocated at a fixed time before the aircraft's preferred landing time. This memorandum reports on a computer simulation study to demonstrate and quantify the effect of the time horizon method. GRA

N90-11724# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
ON THE GENERATION OF A VARIABLE STRUCTURE AIRPORT SURFACE TRAFFIC CONTROL SYSTEM
JACQUES J. DEMAEL and ALEXANDER H. LEVIS Aug. 1989 25 p
(Contract N00014-84-K-0519)
(AD-A211306; LIDS-P-1899) Avail: NTIS HC A02/MF A01 CSCL 17/7

A quantitative approach for modeling variable structure decision making organizations is presented. In these organizations, the interactions between the decisionmakers can change, depending on the task being processed. Using Colored Petri Nets as the appropriate mathematical formalism, an algorithm is presented for generating such variable structures. The approach is illustrated through the modeling and design of a hypothetical Airport Surface Traffic Control System. GRA

N90-11729 Civil Aviation Authority, London (England). Air Traffic Control Evaluation Unit.
THE 1987 SURVEY OF TRACK KEEPING AND ALTITUDES ON HEATHROW AND GATWICK STANDARD INSTRUMENT DEPARTURE ROUTES (DAY)
C. K. TOWNEND and L. J. WELLS Aug. 1988 84 p
(CAA-PAPER-88010; EU619; REPT-542; ETN-89-95534)
Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom

A summary of the track keeping of aircraft departing from Heathrow and Gatwick, (England), airports between the hours of 0700 to 2300 local time in relation to the published standard instrument departure routes is presented. The results of that survey, showing the variation in aircraft lateral displacement and altitude at specific distances along each route, are presented. ESA

N90-12570# Federal Aviation Administration, Washington, DC. Office of Management Systems.
FAA AIR TRAFFIC ACTIVITY: FISCAL YEAR 1988
1988 200 p
(AD-A211338) Avail: NTIS HC A09/MF A01 CSCL 01/5

Terminal and en route air traffic activity information of the National Airspace System are furnished. The data were reported by the FAA-operated Airport Traffic Control Towers (ATCTs), Air Route Traffic Control Centers (ARTCCs), Flight Service Stations (FSSs), Approach Control Facilities, and FAA contract-operated towers. These reports are used as a guide in determining the need for larger or additional facilities, and possible increases in personnel at existing facilities. GRA

N90-12572 Civil Aviation Authority, London (England). Air Traffic Control Evaluation Unit.
DEVELOPMENT AND EVALUATION AT ATCEU OF EXECUTIVE AND SUPPORT OPERATIONS, PHASE 4A/3D
M. J. DOWSETT, A. E. JOHNSON, and C. S. NARBOROUGH-HALL (Royal Air Force, London, England) Dec. 1988 95 p
(CAA-PAPER-88017; EU404; REPT-508; ETN-89-95246)
Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom

The phase 3c and phase 4a and 3d simulations, concerned with developing and evaluating the executive and support mode (ES) of controller operation proposed in the London air traffic control center development plan are described. Phase 3c examines civil aspects of the ES operation. It concentrates on display and message formats and on automatic coordination procedures. Phase 4a and 3d study problems associated with joint civil/military use of the concepts. Recommendations about areas requiring further development and study are made. ESA

N90-12573 Civil Aviation Authority, London (England). Air Traffic Control Evaluation Unit.
OPERATIONAL TRIAL OF EFFECT OF RAISING MINIMUM STACK LEVEL IN HEATHROW STACKS
A. E. JOHNSON Feb. 1989 25 p
(CAA-PAPER-89003; EU656; REPT-549; ETN-89-95247)
Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, United Kingdom

The results of a field trial to measure the effects upon Heathrow, London, of raising the transition altitude above 6000 ft. are described. The effects were simulated by sterilizing the minimum stack level in the Heathrow stacks for a period from 27 Jun. until 22 Jul. 1988. Subjective opinion was divided as to how much the inbound traffic was penalized. Measurements showed there was very little effect. The questionnaires used for the subjective opinion data are included, as are numerical results recorded during the trial period. The trial period was interrupted for 40 period of the time due to heavy impending traffic. ESA

N90-12574# Federal Aviation Administration, Atlantic City, NJ.
PARALLEL APPROACH SEPARATION AND CONTROLLER PERFORMANCE: A STUDY OF THE IMPACT OF TWO SEPARATION STANDARDS
EARL S. STEIN Nov. 1989 99 p
(Contract F2006D)
(DOT/FAA/CT-TN89/50) Avail: NTIS HC A05/MF A01

A small sample study of the possible impact of altering the separation minimum between aircraft approaches to dependent parallel runways is described. The current standard is 2 nautical miles (nmi) and the proposed new standard is 1.5 nmi. Four full performance level air traffic controllers participated in 12 hours of simulated air traffic control activity in which separation standards were altered in a balanced fashioned after each 1 hour block of simulation. Data were collected on multiple airspace and operator performance variables. Also collected were workload and observer estimates. The goal was to determine if system performance could be improved without compromising safety. Results indicated an increased frequency of landings using the 1.5 nmi standard indicating a finite increase in airport capacity. There were no indications of reduced safety or increased operator workload. Since the data were generated based on a small sample, results should be considered indicative rather than conclusive. Author

N90-12575# Royal Signals and Radar Establishment, Malvern (England).
SOFTWARE FAULT TOLERANCE
L. N. SIMCOX Jun. 1988 33 p Sponsored by the Civil

Aviation Authority, London, England
(RSRE-MEMO-4237; BR108878; ETN-89-94842) Copyright
Avail: NTIS HC A03/MF A01

The principles of software fault tolerance are presented. Various schemes for achieving it are described. Emphasis is placed on the N-version programming and the recovery blocks schemes. The areas of research include reliability modeling, version independence, and system simulation. A description of the use of software fault tolerance in aerospace applications is given. The cost effectiveness is addressed. The potential benefits to air traffic control systems are identified. Areas where further study and research are desirable, are indicated. ESA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-13791
GENERAL DYNAMICS F-16
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 37, Nov. 1989, p. 217-225, 248.
Copyright

A development history and current status evaluation are presented for the F-16 in its various U.S-manufactured and foreign licensee-manufactured forms. Even if no further orders are placed, over 3000 F-16s will eventually be in possession of a total of 17 air forces; total current acquisition planning will eventually raise the total to 4400 aircraft. Attention is given to the changes instituted in weapons and avionics suites over the years since the F-16 first entered service, as well as to prospective incorporations of more powerful engines, larger-area wings, and less stable control laws for FBW supermaneuverability. O.C.

A90-14327
BEECH STARSHIP OCCUPANT PROTECTION EVALUATION IN EMERGENCY LANDING SCENARIO
JAGANNATH GIRI and ED HOOPER (Beech Aircraft Corp., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 14 p.
(SAE PAPER 891015) Copyright

The energy absorption capabilities of the Beech Starship fuselage are demonstrated. Drop test results of the two barrels showed a good correlation. It was found that, even at 17.5 ft/sec drop velocity, the fuselage maintained its original shape and the dummy head. A plot of the dummy lumbar force versus drop velocity is presented. K.K.

A90-14330* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPACT EVALUATION OF COMPOSITE FLOOR SECTIONS
RICHARD L. BOITNOTT (NASA, Langley Research Center; U.S. Army, Army Aviation Research and Technology Activity, Hampton, VA) and EDWIN L. FASANELLA (Planning Research Corp., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 17 p. refs
(SAE PAPER 891018) Copyright

Graphite-epoxy floor sections representative of aircraft fuselage construction were statically and dynamically tested to evaluate their response to crash loadings. These floor sections were fabricated using a frame-stringer design typical of present aluminum aircraft without features to enhance crashworthiness. The floor sections were tested as part of a systematic research program developed to study the impact response of composite components of increasing complexity. The ultimate goal of the research program is to develop crashworthy design features for future composite aircraft. Initially, individual frames of six-foot diameter were tested both statically and dynamically. The frames were then used to construct built-up floor sections for dynamic tests at impact velocities of approximately 20 feet/sec to simulate survivable crash velocities. In addition, static tests were conducted to gain a better understanding of the failure mechanisms seen in the dynamic tests. Author

A90-14341
PROPELLER DEVELOPMENT FOR THE RUTAN VOYAGER
JOHN G. RONCZ (Gemini Technologies, Inc., Granger, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 14 p. refs
(SAE PAPER 891034) Copyright

The development of suitable propeller designs for the Voyager, the first aircraft to circumnavigate the globe nonstop without refueling, is described. The basic design theory involved is reviewed, and how nonuniform flowfield effects are taken into account is shown. The design of the propellers and the blade airfoil is examined, taking the rationale and methods involved into consideration. The performance of the propellers during the flight is briefly described. C.D.

A90-14353
DESIGNING THE NEXT GENERATION FLYING TEST BED
I. C. BELL (Pratt and Whitney Canada, Longueuil) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 16 p. refs
(SAE PAPER 891049) Copyright

A B 720 B aircraft purchased in 1985 was modified to serve as a flying engine test bed for turboprop engines. The major structural changes to the airliner included the extension of the nose for attachment of turboprop nacelles, the addition of a winglike pylon on the port side of the forward fuselage, and modification of the number three engine pylon for structural support of a large, high bypass turbofan engine. Attention is presently given to the pitot-static systems used, which underwent several modifications in order to alleviate performance difficulties. O.C.

A90-14361
INFLUENCE OF JOINT FIXITY ON THE STRUCTURAL STATIC AND DYNAMIC RESPONSE OF A JOINED-WING AIRCRAFT. I - STATIC RESPONSE
HUNG-HSI LIN, JITAI JHOU, and RONALD STEARMAN (Texas, University, Austin) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 16 p. refs
(SAE PAPER 891060) Copyright

A comparative study is made between the internal stress resultants in a joined-wing structure that arise from employing eight different wing-joint fixities for an assumed flight loading condition. The joint fixity refers to the type of attachment that connects the rear wing tips to the forward wing tip or inboard spanwise point. The study is carried out employing both experimental as well as computational investigations. The study of the eight joint configurations indicates that the rigid joint is the most practical. This conclusion was based on a comparison as to which wing joint provided the largest reduction in the classical cantilever-wing root-bending moment. This moment reduction was subject to the constraint that no excessive joint reactions are introduced which tend to promote stiffness instabilities of the rear wing (which acts as a strut brace to the forward wing). Author

A90-14362
FATIGUE AND ELECTROMAGNETIC INTERFERENCE TEST FOR ELECTRO-IMPULSE DE-ICING
G. W. ZUMWALT (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 13 p. refs
(SAE PAPER 891062) Copyright

Electro-Impulse De-Icing (EIDI) has been studied and developed at Wichita State University for the past six years in ten icing wind tunnel tests and three sets of flights tests. However, questions remained about the system endurance over a life-time of use and about electromagnetic compatibility. These were addressed in tests of both metal and composite leading edges. Energy levels used

were those determined necessary in the earlier tunnel and flight tests. Failures for the aluminum leading edges were found only in poorly designed coil brackets and in a pre-stressed rivet hole. No damage could be found with the composite model. Electromagnetic radiation was found to be well contained in an aluminum wing. Exposed lead wires were high power emitters and these had to be fully shielded for the composite model to meet the specifications. The emissions were broadband with no significant peak frequencies. Author

A90-14364
METHODS OF SAFETY ANALYSIS FOR BEECH MODEL 2000 - STARSHIP 1
BRUCE L. LUTZ (Beech Aircraft Corp., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 18 p.
(SAE PAPER 891064) Copyright

Success Tree Modeling provided a methodical, organized method to evaluate multiple failures and ensure that the Beech Model 2000 (Starship 1) meets safety level requirements. Failure Mode Effect Analyses complemented these evaluations aiding in the validation process. This functional approach allows the models to be applicable to any other aircraft (from small singles to large multiengine transports) and spacecraft. In addition, the methodology can be used to assess the safety and operational performance of any function which depends upon a complex system where multiple failures are considered. Author

A90-14368
AUTOMATED AIRCRAFT CONFIGURATION DESIGN AND ANALYSIS
JAN ROSKAM and SEYYED MALAEK (Kansas, University, Lawrence) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 20 p. Research supported by the General Dynamics Corp. and University of Kansas. refs
(SAE PAPER 891072) Copyright

A development status evaluation is presented for an interactive, user-friendly computer program based on PASCAL and FORTRAN, designated 'Advanced Aircraft Analysis' (AAA), for the performance of preliminary aircraft configuration design and analysis functions. The AAA process is used to give attention to such critical factors in design as configuration selection, cockpit and fuselage layout, landing gear layout, wing layout, weight sizing, performance sizing, high lift devices, drag polars, stability and control characteristics, and these characteristics' derivatives. Applications of AAA to date have encompassed agricultural aircraft, business jets, regional airliners, amphibious aircraft, military transports, and fighters. O.C.

A90-14369
DESIGNING THE V-22 'OSPREY' TILTROTOR V/STOL AIRCRAFT FOR MAINTENANCE AND SERVICEABILITY
ALAN W. MOFFATT (Bell Helicopter Textron, Fort Worth, TX) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 11 p.
(SAE PAPER 891075) Copyright

This paper deals with the development and application of maintenance and serviceability-related design constraints during the design of the V-22 'Osprey' multiservice aircraft. The V-22 program has been unique in its early and continuous application of supportability emphasis during the aircraft development process. Integrated teams of logistics and design engineers were formed commencing with the beginning of the preliminary design phase to ensure maximum aircraft supportability. Mockups were used extensively to develop serviceability concepts and evaluate conceptual designs. Design approaches to enhance supportability were stressed throughout the development process. This paper highlights the effectiveness of the supportability enhancement process by reviewing the process itself and describing some of its resulting effects on the design of the 'Osprey'. Because of the early and continuous emphasis on maintenance and serviceability during the V-22 design process, the V-22 'Osprey' will be the most supportable aircraft in its weight class in the Department of Defense inventory. Author

A90-14370
ENHANCED COMBAT DAMAGE TOLERANCE/SUPPORTABILITY FOR IMPROVED COMBAT SUSTAINABILITY
ALLAN H. JOHNSON and JACK AVERY (Boeing Military Airplanes, Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 16 p.
(SAE PAPER 891078) Copyright

Future Military Aircraft will be required to maintain a higher level of combat effectiveness than their predecessors. This can be achieved by increasing threat survivability and providing rapid repair for combat damage. Achieving these goals will require full integration of survivability and supportability requirements early in the design process. This paper discusses future military airframe combat damage tolerance design requirements and features, relationship between supportability and survivability, peacetime support needs, and presents key elements of a design approach that ensures achieving combat mission effectiveness. Author

A90-14372
INTERIOR NOISE CONTROL OF THE SAAB 340 AIRCRAFT
URBAN EMBORG (Saab-Scania AB, Linkoping, Sweden) and WILLIAM G. HALVORSEN SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 13 p. refs
(SAE PAPER 891080) Copyright

A comprehensive development program was performed on the Saab 340 aircraft, with the goal of reducing sound levels at the passenger seats in the plane of the propellers. The test program included in-flight sound measurements and operating deflection shape measurements on the fuselage structure, for various propeller speeds and synchrophase angles, and structural frequency response tests. The noise control approach developed was to reduce the low-order fuselage response with the addition of viscoelastic tuned dampers to the fuselage frames in the plane of the propellers. Author

A90-14373
FINITE ELEMENT CALCULATIONS OF THE INTERIOR NOISE OF THE SAAB 340 AIRCRAFT
PETER GORANSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 18 p.
(SAE PAPER 891081) Copyright

The complex behavior of a fuselage-cavity system in a modern propeller aircraft has been analyzed with the finite element method. In the analysis the interaction between the fluid and the structure has been taken into account in a physical coupling formulation. The results obtained show that, at some frequencies, this coupling is very important for the vibro-acoustic system response. The eigenfrequencies and eigenmodes of the fuselage-cavity found in the analysis are compared with experimental modal analysis on a mock-up of the aircraft. The agreement is very good from 10-130 Hz. Especially the modes with strong coupling are well pronounced in the experiments. Author

A90-14374
BEECH STARSHIP INTERIOR NOISE EXPERIMENTAL STUDIES
JAGANNATH GIRI and RON HUND (Beech Aircraft Corp., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 14 p.
(SAE PAPER 891082) Copyright

Acoustic tests have been conducted to ascertain the noise transmission characteristics of two composite fuselage primary structure panels representative of those employed by a novel turboprop-powered aircraft; while both panels were of graphite-epoxy, one possessed honeycomb-core sandwich construction with a Nomex core, while the other was of conventional stringer-type construction. Attention is given to the details of the

test instrumentation as well as the most pertinent results. The honeycomb sandwich-core panel produced the lowest acoustical transmission results. O.C.

A90-14375
EFFECT OF AN ISOLATED SHELL ON INTERIOR NOISE LEVELS IN A TURBOPROP AIRCRAFT
RAMASAMY NAVANEETHAN and ROBERT L. HOWES (Cessna Aircraft Co., Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 6 p. refs
(SAE PAPER 891083) Copyright

A noise control strategy for a small twin engine turboprop aircraft is evaluated. The noise control strategy consisted of a composite shell suspended inside the aircraft on isolation mounts. The evaluation consisted of a ground test program on component panels to select the shell material and a flight test program on the aircraft with and without the interior shell installed. Results from both phases are presented. Author

A90-14555
DYNAMIC STIFFNESS OF A HYDRAULIC DAMPER IN THE SYSTEM OF A FRONT LANDING GEAR STRUT [O DINAMICHESKOI ZHESTKOSTI GIDRAVLICHESKOGO DEMPFERA V SISTEME NOSOVOI STOIKI SHASSI]
V. A. BESPALOV, V. S. METRIKIN, and M. A. PEISEL' Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 3-6. In Russian.
Copyright

A mathematical model is developed which describes the hydraulic damper of a front landing gear strut with allowance for the support structure characteristics of the strut. The model proposed here makes it possible to evaluate the efficiency of the hydraulic damper from the damping coefficients of its support structure and links. The discussion is illustrated by specific examples. V.L.

A90-14556
STRUCTURAL ANALYSIS OF THE HORIZONTAL TAIL SURFACES OF SUBSONIC TRANSPORT AIRCRAFT [STRUKTURNYI ANALIZ PLOSHCHADI GORIZONTAL'NOGO OPERENIIA DOZVUKOVOGO TRANSPORTNOGO SAMOLETA]
V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 6-10. In Russian.
Copyright

The structure of the horizontal tail surfaces of subsonic transport aircraft is analyzed with allowance for alignment tolerances, static stability margin, and zero-lift balancing. The analysis has made it possible to develop an algorithm for solving problems involving the determination of maximum weight requirements for the implementation of novel design solutions. The discussion is illustrated by an example for a hypothetical aircraft. V.L.

A90-14580
INCREASING THE HEAT CONDUCTIVITY OF ELASTIC DAMPING ELEMENTS OF MR MATERIAL [O POVYSHENII TEPLOPROVODNOSTI UPRUGODEMPFIRUIUSHCHIKH ELEMENTOV IZ MATERIALA MR]
A. I. BELOUSOV, G. V. LAZUTKIN, and A. M. ZHIZHKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 84-86. In Russian.
Copyright

Experiments were carried out to investigate the possibility of increasing the heat conductivity of elastic damping elements made of MR material (a porous nonwoven metal material made of metal wires) through the use of reinforcing cords made of a highly heat-conductive metal material. It is shown that the use of copper cords makes it possible to increase the heat conductivity of MR material by a factor of 10, with a 16-33-percent increase in its damping capacity. The copper reinforcement produces practically no changes in the elastic properties of the material. V.L.

A90-14584
DETERMINATION OF THE EFFECTIVE AREAS OF THE MIXING EXHAUST DUCTS OF A BYPASS ENGINE FROM AUTONOMOUS TEST RESULTS [OPREDELENIE EFFEKTIVNYKH PLOSHCHADEI KANALOV ZATURBINNOGO USTROISTVA TRDD PO REZUL'TATAM AVTONOMNYKH ISPYTANII]
V. I. VASIL'EV, I. V. ZEMNUKHOV, S. IU. KRASHENINNIKOV, M. D. MIRSKII, and A. D. PORTNOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 93, 94. In Russian.
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The effective cross-sectional areas of the mixing exhaust ducts of a bypass engine are determined experimentally as a function of the exhaust configuration using small-scale (Re 10 to the 6th) and large-scale (Re 10 to the 7th) models. Dependences of the effective cross-sectional area on the exhaust geometry are obtained for lobe-type mixing exhausts. It is noted that the efficiency of bypass engine control with allowance for actual changes in the effective cross-sectional area is 20-30 lower than in the case of control based on changes in the geometrical area, which should be taken into account in the analysis of engine performance. V.L.

A90-14615#
AEROELASTIC CHARACTERISTICS OF WINGS IN SUBSONIC FLOW
ZHENGYIN YE and LINGCHENG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 7, Oct. 1989, p. 456-463. In Chinese, with abstract in English. refs

A numerical method is presented for predicting the static and dynamic aeroelastic characteristics of wings in subsonic flow. The method is based on the simultaneous time integration of the structural equation and dynamic fluid equation-velocity potential equation. The velocity potential equation is solved by a new, efficient aerodynamic force calculation which requires considerably less computer time than Green's function method. For any flying state, the present method can simulate the history of wing movement in the time domain. It can give not only the critical flutter speed and the subcritical and supercritical process, but also the more complicated vibration process. It can simulate the response of wings to any in-flight disturbance and can calculate the static aeroelastic characteristics directly. A rectangular wing is addressed as a computational example. C.D.

A90-15560
DURABILITY CHARACTERISTICS OF THE LAK-12 LETUVA GLIDER MADE OF COMPOSITE MATERIALS AT THE STAGE OF CERTIFICATION [KHARAKTERISTIKI EKSPLUATATSIONNOI ZHIVUCHESTI PLANERA LAK-12 'LETUVA', VYPOLNENNOGO IZ KOMPOZITNYKH MATERIALOV, NA ETAPE SERTIFIKATSII]
A. E. USHAKOV, I. P. BAREISHIS, and V. V. PAULAUSKAS (Kaunasskii Politekhnicheskii Institut, Kaunas; Spetsial'noe Konstruktorsko-Tekhnologicheskoe Biuro Sportivnoi Aviatsii TsK DOSAAF, Prenai, Lithuanian SSR) Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), Sept.-Oct. 1989, p. 878-883. In Russian.
Copyright

A method is presented for investigating the durability characteristics of the composite structural elements of a glider at the stage of certification. The initial conditions, testability and repairability characteristics are determined. Results of the full-scale testing of the durability of glider structures are presented. V.L.

A90-15746
ADVANTAGE AIRBUS?
GUY NORRIS Flight International (ISSN 0015-3710), vol. 136, Oct. 21, 1989, p. 28, 30, 31.
Copyright

The overriding development objectives of the A330 and A340 airliners have been the reduction of drag and weight to minimize

fuel consumption and operating costs. Taken together with other advanced technologies incorporated in these designs, these improvements represent a total savings for a fleet of 10 aircraft of $230 million over 15 years. Emphasis has been given to increasing the content of (1) Al-Li alloys, (2) polymeric matrix composites, and (3) metal-matrix composites, while decreasing the proportion of conventional Al alloys, Ti alloys, and specialty steels. Aerodynamic drag reductions are obtained through laminar flow wing surface area maximization; a drag reduction of 10 percent is expected. O.C.

A90-15877#
NMG - A SYSTEM OF NUMERICAL REPRESENTATION OF AIRCRAFT GEOMETRY [NMG - SYSTEM NUMERYCZNEGO ODWZOROWANIA GEOMETRII SAMOLOTU]
ANDRZEJ KRAWCZYK (OBR-SK, Mielec, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 44, April 1989, p. 3-6. In Polish. refs

The paper presents the mathematical foundations of the NMG (Numerical Master Geometry) system for the representation of aircraft geometry. The possibility of using this system on the IBM XT computer is emphasized. B.J.

A90-16624
AIRFRAME STRUCTURAL DESIGN: PRACTICAL DESIGN INFORMATION AND DATA ON AIRCRAFT STRUCTURES
MICHAEL CHUNG-YUNG NIU (Lockheed Aeronautical Systems Co., Burbank, CA) Los Angeles/Hong Kong, Technical Book Co./Conmilit Press, Ltd., 1988, 618 p. refs
Copyright

The present volume constitutes a comprehensive guide to state-of-the-art practices in aircraft structural design and their embodiment in integrated CAD/CAM procedures. These practices encompass metallic primary structure materials that are fabricated either discretely, through the joining of plates and sheets, or integrally through milling, and polymer-matrix composite materials built up as laminates and either bonded or mechanically joined. Attention is given to the incorporation of mechanical, hydraulic, and electrical subsystems, the details of integral fuel tankage, fail-safe principles for pressurized cabin-forming fuselages, and the interface between wing and fuselage structures and landing gears of various configurations. O.C.

N90-11731# National Center for Atmospheric Research, Boulder, CO. Atmospheric Technology Div.
SCIENTIFIC JUSTIFICATION AND DEVELOPMENT PLAN FOR A MID-SIZED JET RESEARCH AIRCRAFT
WILLIAM A. COOPER, WARREN B. JOHNSON, JAMES E. RAGNI, GILBERT L. SUMMERS, and M. NORMAN ZRUBEK Jun. 1989 71 p
(Contract NSF ATM-87-09659)
(PB89-208995; NCAR/TN-337-EDD) Avail: NTIS HC A04/MF A01 CSCL 01/3

Extensive inputs from the atmospheric sciences community, especially those at the Second NCAR Research Aircraft Fleet Workshop in April 1987, have identified a number of critical observational needs of research studies in global climate, atmospheric chemistry, mesoscale storm structure and dynamics, cloud physics, and stratospheric-tropospheric exchange that cannot be met with NCAR's current aircraft. The 1987 Fleet Workshop, as well as a similar workshop held earlier in 1982, resulted in strong recommendations that NCAR replace its aging Sabreliner with an advanced mid-sized jet to provide these needed capabilities. These inputs are followd up, and a plan for implementation of these recommendations is offered. Author

N90-11732*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLUTTER CLEARANCE OF THE F-18 HIGH-ANGLE-OF-ATTACK RESEARCH VEHICLE WITH EXPERIMENTAL WINGTIP INSTRUMENTATION PODS
LAWRENCE C. FREUDINGER Oct. 1989 21 p
(NASA-TM-4148; H-1528; NAS 1.15:4148) Avail: NTIS HC A03/MF A01 CSCL 01/3

An F-18 aircraft was modified with wingtip instrumentation pods for use in NASA's high-angle-of-attack research program. Ground vibration and flight flutter testing were performed to clear an acceptable flight envelope for the aircraft. Flight test utilized atmospheric turbulence for structural excitation; the aircraft displayed no adverse aeroelastic trends within the envelope tested. The data presented in this report include mode shapes from the ground vibration and estimates of frequency and damping as a function of Mach number. Author

N90-11733*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
DEVELOPMENT OF DIRECT-INVERSE 3-D METHODS FOR APPLIED TRANSONIC AERODYNAMIC WING DESIGN AND ANALYSIS Final Report, Oct. 1985 - Aug. 1989
LELAND A. CARLSON Oct. 1989 394 p
(Contract NAG1-619; TAMRF PROJ. RF-5373)
(NASA-CR-186036; NAS 1.26:186036; TAMRF-5373-8903)
Avail: NTIS HC A17/MF A03 CSCL 01/3

An inverse wing design method was developed around an existing transonic wing analysis code. The original analysis code, TAWFIVE, has as its core the numerical potential flow solver, FLO30, developed by Jameson and Caughey. Features of the analysis code include a finite-volume formulation; wing and fuselage fitted, curvilinear grid mesh; and a viscous boundary layer correction that also accounts for viscous wake thickness and curvature. The development of the inverse methods as an extension of previous methods existing for design in Cartesian coordinates is presented. Results are shown for inviscid wing design cases in super-critical flow regimes. The test cases selected also demonstrate the versatility of the design method in designing an entire wing or discontinuous sections of a wing. Author

N90-11734# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Technology Div.
PILOTLESS AIRPLANES
5 Jul. 1989 83 p Transl. into ENGLISH of Guo Fang Gong Ye Chu Ban She (Peoples Republic of China), May 1981 p 1-72
(AD-A211719; FTD-ID(RS)T-0392-89) Avail: NTIS HC A05/MF A01 CSCL 01/3

This book provides a concise introduction to pilotless airplanes, using every-day, easy-to-understand language and clearly drawn illustrations. The structural characteristics of pilotless airplanes are discussed, and a history of their development is provided. Special emphasis is given to the problem of how control systems guide pilotless airplanes in carrying out a variety of tasks. Examples of the uses of pilotless airplanes are given, and projections are made concerning their future prospects. Topics discussed include: Take-off and recovery; Essentials of their control systems; Automatic pilot; Navigation equipment; and Telemetry and remote control; Uses and developmental trends -- As target drones; Pilotless reconnaissance planes as electronic opposition devices, warplanes, specimen collectors and observation planes, planes for scientific studies, and geological prospecting planes. GRA

N90-11735# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli di Combattimento.
PROBLEMS RELATED TO THE ACQUISITION, PROCESSING AND UTILIZATION OF THE MODAL PARAMETERS MEASURED IN FLIGHT TESTS IN ORDER TO OBTAIN THE FULL ENVELOPE FOR FLUTTER [PROBLEMATICHE LEGATE ALL'ESTRAZIONE, ALL'ELABORAZIONE ED AL SUCCESSIVO UTILIZZO DEI PARAMETRI MODALI MISURATI IN VOLO ALLO SCOPO DI RAGGIUNGERE IL PIENO INVILUPPO DAL PUNTO DI VISITA DEL FLUTTER]
M. GUADAGNO, G. GUIFFRE, and M. MARCHITTI (Aeritalia S.p.A., Caselle Torinese, Italy) 1987 23 p In ITALIAN Presented at the 9th Congresso Nazionale della Associazione Italiana di Aeronautica ed Astronautica, Palermo, Italy, 26-28 Oct. 1987
(ETN-89-95210) Avail: NTIS HC A03/MF A01

Problems related to the aeroelastic flight qualification of the

AMX combat aircraft are discussed. The prediction studies allowed the identification of a certain number of couplings, which were monitored during the test flights. The transducer installed measured the evolution of the design critical frequencies and of those which could generate criticality for given variations in mass or rigidity. The approach is demonstrated functionally and relatively fast to verify the matching of mathematical models and for optimizing signal analysis techniques. ESA

N90-12508*# Analytical Services and Materials, Inc., Hampton, VA.
LONG-RANGE LFC TRANSPORT
WERNER PFENNINGER *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 89-115 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/3

M = 0.83 Laminar Flow Control (LFC) transports, carrying large percentage payloads over a range of 20000 kilometers at cruise L/D's of 39 appear feasible with large space externally braced wings, external fuel pods, active controls, and 70 percent laminar flow on wing and tail surfaces, engine nacelles and struts, and a turbulent fuselage. A combination of a swept-forward inboard and a swept-back outer wing appears superior overall, especially for laminar flow and eliminating leading edge contamination probably caused by flyspecks and ice crystals. Wing divergence appears controllable by a combination of various methods. Wind-mounted superfans with extensive laminar flow on their nacelles appear practical. Their dominant tone noise is below the frequency range of the most strongly amplified TS-waves. Author

N90-12509*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
DEVELOPMENT FLIGHT TESTS OF JETSTAR LFC LEADING-EDGE FLIGHT TEST EXPERIMENT
DAVID F. FISHER and MICHAEL C. FISCHER (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 117-140 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/3

The overall objective of the flight tests on the JetStar aircraft was to demonstrate the effectiveness and reliability of laminar flow control under representative flight conditions. One specific objective was to obtain laminar flow on the JetStar leading-edge test articles for the design and off-design conditions. Another specific objective was to obtain operational experience on a Laminar Flow Control (LFC) leading-edge system in a simulated airline service. This included operational experience with cleaning requirements, the effect of clogging, possible foreign object damage, erosion, and the effects of ice particle and cloud encounters. Results are summarized. B.G.

N90-12511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE OF LAMINAR-FLOW LEADING-EDGE TEST ARTICLES IN CLOUD ENCOUNTERS
RICHARD E. DAVIS, DAL V. MADDALON, and RICHARD D. WAGNER *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 163-193 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/3

An extensive data bank of concurrent measurements of laminar flow (LF), particle concentration, and aircraft charging state was gathered for the first time. From this data bank, 13 flights in the simulated airline service (SAS) portion were analyzed to date. A total of 6.86 hours of data at one-second resolution were analyzed. An extensive statistical analysis, for both leading-edge test articles, shows that there is a significant effect of cloud and haze particles on the extent of laminar flow obtained. Approximately 93 percent of data points simulating LFC flight were obtained in clear air conditions; approximately 7 percent were obtained in cloud and haze. These percentages are consistent with earlier USAF and NASA estimates and results. The Hall laminar flow loss criteria was verified qualitatively. Larger particles and higher particle concentrations have a more marked effect on LF than do small particles. A particle spectrometer of a charging patch are both acceptable as diagnostic indicators of the presence of particles detrimental to laminar flow. Author

N90-12512*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATED AIRLINE SERVICE EXPERIENCE WITH LAMINAR-FLOW CONTROL LEADING-EDGE SYSTEMS
DAL V. MADDALON, DAVID F. FISHER, LISA A. JENNETT (National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.), and MICHAEL C. FISCHER *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 1 p 195-218 Dec. 1987
Avail: NTIS HC A14/MF A02 CSCL 01/3

The first JetStar leading edge flight test was made November 30, 1983. The JetStar was flown for more than 3 years. The titanium leading edge test articles today remain in virtually the same condition as they were in on that first flight. No degradation of laminar flow performance has occurred as a result of service. The JetStar simulated airline service flights have demonstrated that effective, practical leading edge systems are available for future commercial transports. Specific conclusions based on the results of the simulated airline service test program are summarized. Author

N90-12544*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND TEST OF AN NLF WING GLOVE FOR THE VARIABLE-SWEEP TRANSITION FLIGHT EXPERIMENT
ED G. WAGGONER, RICHARD L. CAMPBELL, PAM S. PHILLIPS, and JAMES B. HALLISSY *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 753-776 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

Gloves for M = 0.7 and 0.8 design points were computationally designed and analyzed at conditions over the proposed flight test envelope. The resulting computational pressure distributions were analyzed in a boundary layer stability code. These results indicate that the available pressure distributions offer a wide range of combinations of cross flow and Tollmien-Schlichting N-factors. The glove designs along with the baseline configuration were tested in an entry into the National Transonic Facility. Analysis of the force and moment data showed no significant differences in the performance and stability and control characteristics between the baseline and gloved configurations. The rolling moment constraint was met over the entire flight test envelope for the gloved configuration. Pressure distributions for the NTF test confirmed the design pressure distributions were achieved. However, it was decided that with minor modifications to the inboard region of the glove, useful available data could be significantly increased by adding another row of pressure orifices at span station 167.
Author

N90-12545*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE DESIGN OF AN AIRFOIL FOR A HIGH-ALTITUDE, LONG-ENDURANCE REMOTELY PILOTED VEHICLE
MARK D. MAUGHMER (Pennsylvania State Univ., University Park.) and DAN M. SOMERS *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 777-794 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

Airfoil design efforts are studied. The importance of integrating airfoil and aircraft designs was demonstrated. Realistic airfoil data was provided to aid future high altitude, long endurance aircraft preliminary design. Test cases were developed for further validation of the Eppler program. Boundary layer, not pressure distribution or shape, was designed. Substantial improvement was achieved in vehicle performance through mission specific airfoil designed utilizing the multipoint capability of the Eppler program. Author

N90-12546*# Boeing Commercial Airplane Co., Seattle, WA.
THE 757 NLF GLOVE FLIGHT TEST RESULTS
L. JIM RUNYAN, G. W. BIELAK, R. A. BEHBEHANI, A. W. CHEN,

and ROGER A. ROZENDAAL *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 795-818 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

A major concern in the application of a laminar flow wing design to commercial transports is whether laminar flow can be sustained in the presence of the noise environment due to wing mounted turbofan engines. To investigate this issue, a flight test program was conducted using the Boeing 757 flight research airplane with a portion of the wing modified to obtain natural laminar flow. The flight test had two primary objectives. The first was to measure the noise levels on the upper and lower surface of the wing for a range of flight conditions. The second was to investigate the effect of engine noise on laminar boundary layer transition. The noise field on the wing and transition location on the glove were then measured as a function of the engine power setting at a given flight condition. The transition and noise measurement on the glove show that there is no apparent effect of engine noise on the upper surface transition location. On the lower surface, the transition location moved forward 2 to 3 percent chord. A boundary layer stability analysis to the flight data showed that cross flow disturbances were the dominant cause of transition at most flight conditions. Author

N90-12547*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
F-14 VSTFE AND RESULTS OF THE CLEANUP FLIGHT TEST PROGRAM
ROBERT R. MEYER, BIANCA M. TRUJILLO, and DENNIS W. BARTLETT (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 819-844 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

Flight transition data applicable to swept wings at high subsonic speeds are needed to make valid assessments of the potential for natural laminar flow or laminar flow control for transports of various sizes at various cruise speeds. NASA initiated the variable sweep transition flight experiment (VSTFE) to help establish a boundary layer transition data base for use in laminar flow wing design. The carrier vehicle for this experiment is an F-14, which has variable sweep capability. The variable sweep outer panels of the F-14 were modified with natural laminar flow gloves to provide not only smooth surfaces but also airfoils that can produce a wide range of pressure distributions for which transition location can be determined. The VSTFE program is briefly described and some preliminary glove I flight results are presented. Author

N90-12548*# Boeing Commercial Airplane Co., Seattle, WA.
VARIABLE-SWEEP TRANSITION FLIGHT EXPERIMENT (VSTFE): STABILITY CODE DEVELOPMENT AND CLEAN-UP GLOVE DATA ANALYSIS
ROGER A. ROZENDAAL *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 845-859 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

The primary objective of the Variable Sweep Transition Flight Experiment (VSTFE) was to establish an improved swept wing transition criterion. The development of the Unified Stability System gave a way of quickly examining disturbance growth for a wide variety of laminar boundary layers. The disturbance growth traces shown are too scattered to define a transition criteria to replace the F-111 data band, which has been used successfully to design NLF gloves. Still, a careful review of the clean-up glove data may yield cases for which the transition location is known more accurately. Liquid crystal photographs of the clean-up glove show much spanwise variation in the transition front for some conditions, and this further complicates the analyses. Several high quality cases are needed in which the transition front is well defined and at a relatively constant chordwise station. Author

N90-12550*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATUS REPORT ON A NATURAL LAMINAR-FLOW NACELLE FLIGHT EXPERIMENT Abstract Only
EARL C. HASTINGS, JR., G. K. FAUST, PARMA MUNGUR, CLIFFORD J. OBARA, S. S. DODBELE, JAMES A. SCHOENSTER, and MICHAEL G. JONES (PRC Kentron, Inc., Hampton, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 887-890 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

The natural laminar flow (NLF) nacelle experiment is part of a drag reduction production program, and has the dual objectives of studying the extent of NLF on full scale nacelles in a flight environment and the effect of acoustic disturbance on the location of transition on the nacelle surface. The experiment is being conducted in two phases: (1) an NLF fairing was flown on a full scale Citation nacelle to develop the experiment technique and establish feasibility; (2) full scale, flow through, NLF nacelles located below the right wing of an experimental NASA OV-1 aircraft are evaluated. The measurements of most interest are the static pressure distribution and transition location on the nacelle surface, and the fluctuating pressure levels associated with the noise sources. Data are collected in combinations of acoustic frequencies and sound pressure levels. The results of phase 2 tests to date indicate that on shape GE2, natural laminar flow was maintained as far aft as the afterbody joint at 50 percent of the nacelle length. An aft facing step at this joint caused premature transition at this station. No change was observed in the transition pattern when the noise sources were operated. Author

N90-12551*# General Electric Co., Cincinnati, OH.
NACELLE DESIGN
G. K. FAUST and PARMA MUNGUR *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 891-907 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

The external cowlings of engine nacelles on large turbofan powered aircraft are good candidates for application of natural laminar flow. These nacelles usually have shorter characteristic lengths than other candidate surfaces such as wings and fuselages and therefore have lower characteristic Reynolds numbers. A conceptive figure of the natural flow nacelle (NLF) is shown. On the typical nacelle the flow accelerates to a curvature induced velocity peak near the lip and then decelerates over the remainder of the nacelle length. Transition occurs near the start of the deceleration, so turbulent flow with high friction coefficient exists over most of the nacelle length. On the other hand, the NLF nacelle is contoured to have an accelerating flow over most of its length, so transition is delayed, and a relatively lower friction drag exists over most of the nacelle. The motivation for development of the LFN is a potential 40 to 50 percent reduction in nacelle friction drag. Author

N90-12552*# PRC Kentron, Inc., Hampton, VA.
NACELLE AERODYNAMIC PERFORMANCE
CLIFFORD J. OBARA and S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA.) *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 908-913 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 01/3

The boundary layer transition location was measured on a nacelle shape using the sublimating chemical flow visualization technique. This technique involves coating the surface with a thin film of volatile chemical solid, which, during exposure to a free stream airflow, rapidly sublimates in the turbulent boundary layer as a result of high shear stress and high mass transfer near the surface. Transition is indicated because the chemical coating remains relatively unaffected in the laminar region due to lower shear and low mass transfer. The slow response time of the chemical in a laminar boundary allowed for two test conditions during the same flight. The aircraft was first flown at the desired airspeed and altitude with the noise source off. Once a pattern had developed, the noise source was turned on to the desired

setting and a new chemical pattern was sought. In this fashion a direct comparison of the effect of the noise could be determined.
Author

N90-12580*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
;NTEGRATED MULTIDISCIPLINARY OPTIMIZATION OF ROTORCRAFT: A PLAN FOR DEVELOPMENT
HOWARD M. ADELMAN, ed. and WAYNE R. MANTAY, ed. May 1989 83 p
(NASA-TM-101617; NAS 1.15:101617; AVSCOM-TM-89-B-004)
Avail: NTIS HC A05/MF A01 CSCL 01/3

This paper describes a joint NASA/Army initiative at the Langley Research Center to develop optimization procedures aimed at improving the rotor blade design process by integrating appropriate disciplines and accounting for important interactions among the disciplines. The paper describes the optimization formulation in terms of the objective function, design variables, and constraints. Additionally, some of the analysis aspects are discussed, validation strategies are described, and an initial attempt at defining the interdisciplinary couplings is summarized. At this writing, significant progress has been made, principally in the areas of single discipline optimization. Accomplishments are described in areas of rotor aerodynamic performance optimization for minimum hover horsepower, rotor dynamic optimization for vibration reduction, and rotor structural optimization for minimum weight.

N90-12581*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GENERAL APPROACH AND SCOPE
HOWARD M. ADELMAN and WAYNE R. MANTAY (Army Aviation Systems Command, Hampton, VA.) *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 3-10 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

This paper describes a joint activity involving NASA and Army researchers at the NASA Langley Research Center to develop optimization procedures aimed at improving the rotor blade design process by integrating appropriate disciplines and accounting for all of the important interactions among the disciplines. The disciplines involved include rotor aerodynamics, rotor dynamics, rotor structures, airframe dynamics, and acoustics. The work is focused on combining these five key disciplines in an optimization procedure capable of designing a rotor system to satisfy multidisciplinary design requirements. Fundamental to the plan is a three-phased approach. In phase 1, the disciplines of blade dynamics, blade aerodynamics, and blade structure will be closely coupled, while acoustics and airframe dynamics will be decoupled and be accounted for as effective constraints on the design for the first three disciplines. In phase 2, acoustics is to be integrated with the first three disciplines. Finally, in phase 3, airframe dynamics will be fully integrated with the other four disciplines. This paper deals with details of the phase 1 approach and includes details of the optimization formulation, design variables, constraints, and objective function, as well as details of discipline interactions, analysis methods, and methods for validating the procedure.
K.C.D.

N90-12582*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROTOR BLADE AERODYNAMIC DESIGN
JOANNE L. WALSH and KEVIN W. NOONAN (Army Aviation Systems Command, Hampton, VA.) *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 10-13 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

Aerodynamic performance aspects of rotor blade design are presented. Design considerations, aerodynamic constraints and design variables are described. K.C.D.

N90-12583*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROTOR BLADE DYNAMIC DESIGN
JOCELYN I. PRITCHARD, HOWARD M. ADELMAN, and WAYNE R. MANTAY (Army Aviation Systems Command, Hampton, VA.) *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 13-17 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

The rotor dynamic design considerations are essentially limitations on the vibratory response of the blades which in turn limit the dynamic excitation of the fuselage by forces and moments transmitted to the hub. Quantities which are associated with the blade response and which are subject to design constraints are discussed. These include blade frequencies, vertical and inplane hub shear, rolling and pitching moments, and aeroelastic stability margin. K.C.D.

N90-12584*# Army Aviation Systems Command, Hampton, VA. Structural Dynamics Div.
ROTOR BLADE STRUCTURAL DESIGN
MARK W. NIXON *In* NASA, Langley Research Center, Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 17-22 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

The structural design of rotor blades is discussed. The various topics associated with the structural design include constraints, load cases, and analyses. K.C.D.

N90-12585*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACOUSTIC DESIGN CONSIDERATIONS: REVIEW OF ROTOR ACOUSTIC SOURCES
RUTH M. MARTIN *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 22-27 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

It is not sufficient to optimize a rotor design in terms of a single noise level calculated for a single flight condition and a single measurement location. The various noise sources, their frequency content, amplitude, and directivity as a function of operating condition must be considered. A summary of the frequency ranges, directivity patterns and the most important operational and design parameters for major rotor noise sources is presented. It is difficult to generalize design requirements for rotor noise because the acoustic output varies so widely depending on the noise source, flight condition, measurement location, and frequency range. However, assuming the rotor must lift a fixed nominal payload and operate over a wide range of flight conditions, three general design guidelines can be stated: (1) minimize tip Mach number; (2) minimize blade thickness in the tip region; and (3) minimize gradients in the spanwise lift distribution in the tip region. Constraints on blade thickness, maximum values for hover tip Mach number, advancing tip Mach number and spanwise lift coefficient gradient will be specified during the aerodynamic, dynamic and structural optimization process. The rotor noise sources to be considered include the low frequency loading and thickness noise, and the higher frequency noise due to blade-vortex interactions (BVI). The analyses to be employed will include the comprehensive rotor analysis and design program CAMRAD and the rotor noise prediction program WOPWOP. K.C.D.

N90-12586*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRFRAME DESIGN CONSIDERATIONS: OVERVIEW
RAYMOND G. KVATERNIK and T. SREEKANTA MURTHY (Planning Research Corp., Hampton, VA.) *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 27-30 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

Aspects of airframe structural dynamics that have a strong influence on rotor design optimization are presented . Primary emphasis is on vibration requirements. The constraints imposed on rotor design by airframe dynamics are discussed. Rotor/airframe modeling enhancements are also described. K.C.D.

N90-12587*# Army Aviation Systems Command, Hampton, VA. Aerostructures Directorate.
VALIDATION OF THE PROCEDURES
WAYNE R. MANTAY *In* NASA, Langley Research Center, Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 31-37 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

Validation strategies are described for procedures aimed at improving the rotor blade design process through a multidisciplinary optimization approach. Validation of the basic rotor environment prediction tools and the overall rotor design are discussed. K.C.D.

N90-12588*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPENDIX: RESULTS OBTAINED TO DATE
JOANNE L. WALSH, ADITI CHATTOPADHYAY, JOCELYN I. PRITCHARD, and MARK W. NIXON (Army Aviation Systems Command, Hampton, VA.) *In its* Integrated Multidisciplinary Optimization of Rotorcraft: A Plan for Development p 38-78 May 1989
Avail: NTIS HC A05/MF A01 CSCL 01/3

Optimization procedures are described for the rotor blade design process by integrating appropriate disciplines and accounting for important interactions among the disciplines. Progress is reported in the areas of aerodynamic performance optimization, dynamic optimization, optimum placement of tuning masses for vibration reduction, and structural optimization. Selected results from these activities are highlighted in this appendix. K.C.D.

N90-12589*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
POWERED-LIFT AIRCRAFT TECHNOLOGY
W. H. DECKERT and J. A. FRANKLIN 1989 36 p Original contains color illustrations
(NASA-SP-501; NAS 1.21:501; LC-89-39482) Avail: SOD HC $4.25 as 033-000-01062-1; NTIS HC A03/MF A01 CSCL 01/3

Powered lift aircraft have the ability to vary the magnitude and direction of the force produced by the propulsion system so as to control the overall lift and streamwise force components of the aircraft, with the objective of enabling the aircraft to operate from minimum sized terminal sites. Power lift technology has contributed to the development of the jet lift Harrier and to the forth coming operational V-22 Tilt Rotor and the C-17 military transport. This technology will soon be expanded to include supersonic fighters with short takeoff and vertical landing capability, and will continue to be used for the development of short- and vertical-takeoff and landing transport. An overview of this field of aeronautical technology is provided for several types of powered lift aircraft. It focuses on the description of various powered lift concepts and their operational capability. Aspects of aerodynamics and flight controls pertinent to powered lift are also discussed. Author

N90-12591# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli da Combattimento.
DEVELOPMENT AND APPLICATIONS OF RELIABILITY AND MAINTAINABILITY DESIGN CRITERIA IN MILITARY AIRCRAFT [SVILUPPO E APPLICAZIONE DI UN PIANO DI AFFIDABILITA' E MANUTENIBILITA' PER UN VELIVOLO MILITARE]
D. ALA, R. BUFFARDI, and B. INGLESE 1989 14 p In ITALIAN; ENGLISH summary
(ETN-89-95208) Avail: NTIS HC A03/MF A01

The reliability and maintainability programs applied to the AM-X aircraft development are described. The requirements, the design criteria, the allocation of requirements at subsystem and equipment level and the relevant analysis and demonstration methods are discussed. The demonstration program is limited to some activities that are estimated sufficient to assess the effectiveness of the system. ESA

N90-12592# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
EULER EQUATION SOLUTIONS APPLIED TO A HELICOPTER ROTOR IN FORWARD MOVING FLIGHT Final Report [RESOLUTION DES EQUATIONS D'EULER APPLIQUEE A UN ROTOR D'HELICOPTERE EN VOL D'AVANCEMENT]
J. SIDES Feb. 1989 63 p In FRENCH
(Contract DRET-88-34-001)
(ONERA-RSF-32/1285-AY-346A; ETN-89-95286) Avail: NTIS HC A04/MF A01

A numeric approach to helicopter rotor design based on Euler equations for nonstationary three dimensional compressible phenomena is presented. This approach is applied to a modeling problem for a thin wing submitted to shocks at transonic speeds. Precise solutions are found for both a fixed wing situation and an oscillating wing in transition, using the approach. Addition of artificial viscosity is not needed thanks to the implicit nature of the approach. ESA

N90-12593# Rolls-Royce Ltd., Derby (England).
WHAT SHOULD BE DONE WITH THOSE NOISY OLD AIRCRAFT
M. J. T. SMITH and V. M. SZEWCZYK 2 Sep. 1988 10 p Presented at the AVMARK International Ltd. Conference of European Aircraft Noise Legislation: Consequences for the Aviation Industry, London, England, 2 Sep. 1988
(PNR90562; ETN-89-95549) Copyright Avail: NTIS HC A02/MF A01

The problem of adapting older noisy aircraft to more stringent noise legislation is discussed. The use of bolt-on hushkits as a means of quieting older aircraft is criticized. Further noise restrictions demand a truly re-engined aircraft. It is predicted that hushkit equipped planes will experience increasing difficulty when operating in noise sensitive airports. The author admits that Rolls Royce has a commercial interest in recommending that older planes be re-engined with stage three turbo fan engines. ESA

N90-12595# Aeronautical Research Labs., Melbourne (Australia).
FPG2: A FLIGHT PROFILE GENERATOR PROGRAM
R. B. MILLER Jul. 1989 48 p
(AD-A212408; ARL-SYS-TM-98; DODA-AR-004-574) Avail: NTIS HC A03/MF A01 CSCL 17/7

This computer program simulates the environment of a strapdown inertial measurement unit in an aircraft executing a user-specified series of idealized maneuvers. The program generates a file containing a sequence of specific forces and angular velocities in body axes coordinates, or a file containing a sequence of integrated (in body axes) specific forces and angular velocities, or both. The sequences are time-tagged, and also include aircraft height. For reference purposes, it generates a file containing a sequence of nominally true position, velocity, and attitude of the aircraft. GRA

N90-12596# Aeronautical Research Labs., Melbourne (Australia).
RAN (ROYAL AUSTRALIAN NAVY) VIBRATION ANALYSIS SYSTEM OPERATOR'S GUIDE
B. D. FORRESTER Apr. 1989 33 p
(AD-A212441; ARL-PROP-TM-441; DODA-AR-004-525) Avail: NTIS HC A03/MF A01 CSCL 01/3

A computerized vibration analysis system consisting of hardware purchased by the Royal Australian Navy and software developed by Aeronautical Research Laboratory has been installed at NAS Nowra. The primary purpose of the system is to detect incipient failure of Wessex helicopter main rotor gear box input pinions. GRA

N90-12597# Aeronautical Research Labs., Melbourne (Australia).
EVALUATION OF A DAMAGED F/A-18 HORIZONTAL STABILATOR Aircraft Structures Technical Memorandum

J. PAUL Feb. 1989 31 p Original contains color illustrations (AD-A212573; ARL-STRUC-TM-503; DODA-AR-005590) Avail: NTIS HC A03/MF A01 CSCL 01/3

This paper describes the results of a static and dynamic structural test on a damaged F/A-18 Horizontal Stabilator. The structure was subjected to incremental static loading and the strains were recorded at each load increment. The structure was then vibrated at its fundamental bending frequency and the thermal emission profile of the critical area was measured using SPATE. GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-13885
HOLOGRAPHIC HEAD-UP DISPLAYS FOR AIR AND GROUND APPLICATIONS

PHILIP J. ROGERS (Pilkington P. E., Ltd., Saint Asaph, Wales) IN: Optical design methods, applications, and large optics; Proceedings of the Meeting, Hamburg, Federal Republic of Germany, Sept. 19-21, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 136-145. refs Copyright

The operating principles and practical feasibility of holographic optical combiners for use in aircraft or automobile head-up displays (HUDs) are discussed and illustrated with drawings and diagrams. The limitations of conventional HUDs based on partially reflecting passive combiners are contrasted with the advantages of the projected-porthole or pupil-relay HUD; the construction of a phase-hologram combiner on dichromated gelatin is described; and the effect of the holographic fringes on an incident light beam is explained. Particular attention is given to techniques for alleviating asymmetric aberration in holographic HUDs, the angular bandwidths of holographic combiners, quasi-axial and off-axis holographic HUDs, and the problems of creating reliable, low-cost, lower-performance holographic HUDs (generally not requiring collimation or outside-view transmission) for automobiles. T.K.

A90-13986#
GPS HOVER POSITION SENSING SYSTEM

P. OKUNIEFF, J. D. ANTONITIS, J. GREEN, R. HOGABOOM, P. SLONAKER (Intermetrics, Inc., Cambridge, MA) et al. IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 187-191.
(Contract DAAB07-87-D-H020)

The feasibility of a GPS Hover Position Sensing System, capable of providing relative horizontal position accuracy to within one meter for three minutes during a hover mission, was investigated. A unique approach to both the real-time data collection and the navigation processing combined with a navigation sensor suite consisting of a GPS receiver and an ASN-141 Inertial Navigation System permits this stringent relative position requirement to be met. Real-time data recording involved software and hardware design and development methods for collecting and time-synchronizing GPS and INS raw measurements, and 'true' hover position information. The validity of the processing algorithms was evaluated using Monte Carlo simulation techniques and actual flight data. The results show that 1.3-meter accuracy is achievable with GPS in spite of large HDOPs and no ionospheric correction data. Author

A90-13999#
ARCHITECTURE OPTIONS FOR GPS/CAROUSEL IV INTEGRATION

BARRY E. GRIFFITHS (Integrity Systems, Inc., Lexington, MA), SAMUEL K. GEORGE (USAF, Oklahoma City Air Logistics Center, OK), JAY S. COOPER, and ROBERT G. MCCARRON (Analytic Sciences Corp., Dracut, MA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 309-317. refs
(Contract F34601-87-C-1655)

The U.S. Air Force wishes to integrate the GPS Phase III receiver with the existing navigation systems of a number of aircraft. The USAF inventory includes about 3000 physically identical Carousel IV-E inertial navigation equipments, suggesting that a common integration satisfying the requirements of all Carousel IV-E users could significantly reduce development and logistics costs below that which would be expected for individual GPS integrations. This paper presents interim results of an effort to define such an integration architecture. C.D.

A90-14012#
THE ACCURACY OF BAROMETRIC ALTIMETERS WITH RESPECT TO GEOMETRIC ALTITUDE

JOHN DOBYNE (ARINC Research Corp., San Diego, CA) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 451-459. refs

This paper presents estimates of the accuracy of barometric altimeters with respect to the geometric altitude above mean sea level. The primary source of altimeter error is found to be the conversion from atmospheric pressure to altitude. The ability of the altimeter to measure air pressure and perform the conversion is quite good in comparison. Global extremes of altimeter error due to variations of atmospheric pressure and worst-case error gradients with vertical and horizontal motion were investigated. The effectiveness of compensation for local surface pressure and ambient air temperature and to estimate the magnitude of the altimeter system error was determined. It is concluded that barometric altimeters should not be used for geometric altitude measurements. C.D.

A90-14354
DESIGN PHILOSOPHY FOR A GENERAL AVIATION TCAS DISPLAY

RICHARD L. NEWMAN and PATRICK BRANS (Avion Systems, Inc., Leesburg, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 15 p. refs
(SAE PAPER 891052) Copyright

Basic human factors principles have been adhered to in the design of a Traffic Advisory and Collision Avoidance System (TCAS) display for single-pilot (general aviation) operation. While the system is of stand-alone type, it is compatible with such other cockpit displays as navigation and weather depiction radar screens. The TCAS control panel has been sized for typical general aviation radio racks. The TCAS modes encompass the normal, the declutter mode, and the select mode for specific targets designated by the pilot by means either of a cursor or the entering of that target's transponder code. O.C.

A90-14356
TWO EFFECTIVE METHODS OF APPROACH AND LANDING BY VISUAL DISPLAY

RENZO YOKOI and KAZUO MATSUBARA (Nihon University, Tokyo, Japan) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 9 p. refs
(SAE PAPER 891054) Copyright

An evaluation is made of the effectiveness of two cockpit visual displays that address the need to improve pilot situational awareness during runway approach and landing operations. The first system considered furnishes a simulated airport runway lighting scheme comparable to night-lighting for visual approaches; the image is projected onto the windscreen by a HUD in all weather conditions. The second system displays the reflector-marked runway contour on the airborne weather radar scope. Both systems are judged to be very effective in facilitating pilot recognition of approach paths. O.C.

N90-12598# Aeritalia S.p.A., Turin (Italy). Flight Test Development.
ACQUISITION AND RECORDING AN AMX A/C. AERITALIA EXPERIENCE AND PRESENT TRENDS
S. CATTUNAR 1987 13 p Presented at the European Telemetry Conference, Aix-en-Provence, France, 1987
(ETN-89-95217) Avail: NTIS HC A03/MF A01

Experimentation with the BUS 1553 B as the active link for all avionic, navigation and armament equipment in an AMX prototype A03 aircraft is described. The system allows for acquisition of 256 parameters from transducer and analog sources. Two different acquisition techniques, through a PCM (pulse code modulation) acquisition system and directly on a magnetic tape recorder, are used. The results of the experimentation helped in developing a unit allowing for considerable savings in track usage. ESA

N90-12599# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Flugversuchstechnik.
AUTOMATIC PROCESSING OF IMAGES FROM THE GRATE FLIGHT TEST TOOL
KLAUS ALVERMANN 24 May 1989 50 p In GERMAN; ENGLISH summary
(DLR-FB-89-28; ISSN-0171-1342; ETN-89-95837) Avail: NTIS HC A03/MF A01; DLR, VB-PL-DO, Postfach 40 60 58, 5000 Cologne, Fed. Republic of Germany, 21 Deutsche marks

The GRATE flight test tool is described. It produces a film, the pictures of which are processed automatically. Objects in the image are identified and their exact position determined. An algorithm necessary for the identification of objects is developed. A tracker (a pipper in a head-up display) and a target (a light on the ground) are developed. The mathematical elements of the algorithms are presented and discussed in detail. The operating efficiency is evaluated. ESA

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g. gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A90-13445#
DEVELOPMENT STUDY OF AIR TURBO-RAMJET FOR FUTURE SPACE PLANE
NOBUHIRO TANATSUGU (Institute of Space and Astronautical Science, Sagamihara, Japan), TAKEKAZU HONDA, YOSHIMASA SAGIYA, and KAZUYUKI HIGASHINO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tanashi, Japan) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 7 p.
(IAF PAPER 89-311) Copyright

The airturboramjet (ATR) engine presently discussed as a candidate propulsion system for prospective aerospaceplanes employs a hydrogen-cooled expander cycle and is accordingly designated ATREX. The engine configuration involves a hydrogen-heatsink precooler for intake air as well as a combustion chamber heat exchanger. It is projected to be capable of furnishing superior specific thrust from sea level/static to 30-km/hypersonic (Mach 6) flight conditions. Attention is given to the test conditions and performance characteristics of the ATREX engine, the materials required for its critical components, and the test apparatus employed. O.C.

A90-13447#
THE CYCLE EVALUATION OF THE ADVANCED LACE PERFORMANCE
A. OGAWARA and T. NISHIWAKI (Mitsubishi Heavy Industries, Ltd., Nagoya Guidance and Propulsion Systems Works, Japan) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 7 p.
(IAF PAPER 89-313) Copyright

The LACE (Liquefied Air Cycle Engine) can be developed more easily than the other types of air-breathing engines and has the higher performances. The key technology of the LACE is to improve the air-liquefaction ratio of heat exchanger, so in this regard, there have been proposed various types of higher liquefaction ratio LACE with the tank return system. In this report, these system performances are estimated under the conditions of 0-50 km altitude and 0-8 Mach, using slush hydrogen as fuel. The required performance for the principal components and the step of development of LACE are also described. Author

A90-14328
CRITERIA FOR GENERAL AVIATION FUEL SYSTEMS CRASHWORTHINESS
A. F. MADAYAG (FAA, Washington, DC) and JOHN W. OLCOTT (Business and Commercial Aviation Magazine, New York) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 13 p.
(SAE PAPER 891016) Copyright

Fuel systems post-crash hazard is the threat to occupant survival posed by fire, smoke, toxic gases, etc., following an impact (crash) sequence. The probability of occupant survival during crash impacts due to fire, smoke, toxic gases, etc., will be enhanced by the inclusion of some general crash survivability design features addressed in this paper. To minimize or prevent thermal deaths and injuries in survivalbe crashes, an improvement in the crash resistance of general aviation fuel systems is necessary. This paper summarizes the General Aviation Safety Panel (GASP) recommendations to the Federal Aviation Administration (FAA) on fuel systems crashworthiness, and presents selected technical presentations given at several GASP public meetings. Author

A90-14350
DESIGN AND DEVELOPMENT OF THE GARRETT F109 TURBOFAN ENGINE
HANS F. MAERTINS, JAY D. BATSON, MARK A. STEELE (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ), and KENNETH W. KRIEGER (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 12 p.
(SAE PAPER 891046) Copyright

The F109-GA-100 engine, flat rated at 1330-pounds thrust at sea level static maximum power conditions, was developed to address the United States Air Force need for a new primary trainer. As such, it required very low fuel consumption, high reliability, and ease of operation. This paper describes the development program and highlights the Engine Structural Integrity Program (ENSIP) approach to the design and the Accelerated Mission Test (AMT) approach to testing, both of which are new approaches to engine development. Solutions to problems encountered are discussed, and a summary of flight test experience is included. Author

A90-14351
GARRETT TPF351-20 TURBOPROP FAN ENGINE DEVELOPMENT
R. D. MILLER (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 10 p.
(SAE PAPER 891047) Copyright

The design methodology applied to the TPF351-20/-20 2000 shp-class, free turbine-powered gearbox turbopropfan engine's configuration has attempted to meet market demands defined by 19-30 passenger regional airliners by applying advanced materials to proven component designs. The design thus obtained achieves the maximum degree of commonality between pusher and tractor engine installations, as well as a high degree of growth capability to ensure continuing applicability in future years to additional regional airliner designs. The pusher configuration is especially

attractive, in virtue of the cabin noise reductions associated with a near-stern propeller plane aft of the cabin. O.C.

A90-14352
SUCCESSFUL PERFORMANCE DEVELOPMENT PROGRAM FOR THE T800-LHT-800 TURBOSHAFT ENGINE
ANDREW A. COSNER and GLYN S. RUTLEDGE (Light Helicopter Turbine Engine Co., Saint Louis, MO) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 13 p.
(SAE PAPER 891048) Copyright

The engine performance development program for the 1200-shp class T800-LHT-800 helicopter powerplant for the U.S. Army's next-generation LHX helicopter began by methodically diagnosing a test engine whose part-power specific fuel consumption deviated from design levels by about 6 percent. On the basis of this effort's findings, configuration changes that could be economically incorporated into production engines were developed; these were found to yield a performance improvement which lay significantly beyond specification requirements. An account is given of valuable lessons from this development program. O.C.

A90-14365
THE VARIABLE CYCLE DIESEL AS AN AIRCRAFT ENGINE
RICHARD P. JOHNSTON SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 8 p.
(SAE PAPER 891065) Copyright

A brief summary of previous significant aircraft diesel engine development and application is presented along with a comparison with the then contemporary state-of-the-art aircraft gasoline engine. Performance results for an Advanced Variable Cycle Diesel (AVCD) engine obtained from a computer simulator code are presented and comparisons made with an identical fixed cycle engine. Some operational benefits of an AVCD engine are discussed along with an alternate method of controlling the engine's precompression turbocompressor. Finally, the altitude capability of an AVCD engine is shown and a description of a 750 SHP AVCD aircraft engine suitable for use on a medium size subsonic business transport plane is presented along with its projected performance. Author

A90-14366
SIMULATION OF A TURBOCOMPOUND TWO-STROKE DIESEL ENGINE
J. A. HARRIS and A. M. YOUSSEF (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 10 p. Research supported by the U.S. Army. refs
(SAE PAPER 891066) Copyright

A FORTRAN computer code has been developed to simulate the performance of a turbocompound two-stroke diesel engine. This powerplant offers the potential for fuel efficiency combined with high power-to-weight ratio, and is being considered for airborne applications such as helicopters and drone aircraft. The simulation code allows the user to specify engine parameters for the diesel core, the turbocharger (in the form of a performance curve), the bottoming turbine, and the intercooler. The program runs in two modes. The user runs the design mode first, in which specification parameters are set and the code sizes the turbomachinery and intercooler. The off-design mode can then be run to see how the resulting engine will perform at off-design values of ambient conditions, fueling rate, and engine speed. Author

A90-14568
VALIDATION OF THE ACCELERATED EQUIVALENT TESTING OF GAS TURBINE ENGINES FOR MULTIVARIANT APPLICATIONS [OBOSNOVANIE USKORENNYKH EKVIVALENTNYKH ISPYTANII GTD MNOGOVARIANTNOGO PRIMENENIIA]
A. S. GISHVAROV, O. V. IVANOV, and R. G. SARVARETDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 49-52. In Russian.
Copyright

The paper is concerned with the problem of selecting the optimal number, conditions, and duration of accelerated equivalent tests for aircraft gas turbine engines designed for use on a variety of aircraft operating in different climatic regions. An approach to the selection of the optimal program of accelerated testing is proposed which makes it possible to obtain a guaranteed estimate of the reliability and service life of the engine for each of all the possible applications. The method proposed here is illustrated by a specific example. V.L.

A90-14569
A MINIMAL PERMISSIBLE RADIAL CLEARANCE IN A GAS TURBINE [MINIMAL'NO DOPUSTIMYI RADIAL'NYI ZAZOR V TURBINE GTD]
R. A. KIRZHNER and B. I. MAMAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 52-56. In Russian.
Copyright

The factors affecting the mimimal permissible radial clearance in a gas turbine, which is sufficient to prevent the dangerous contact between the rotor and the casing, are examined. It is shown that the radial clearance changes with the operating conditions and may be relatively large if special efforts are not made to reduce it. Methods of reducing the permissible radial clearance are discussed. V.L.

A90-14570
ESTIMATION OF THE TECHNICAL RISK CRITERION IN SELECTING THE OPERATING PARAMETERS OF AIRCRAFT GAS TURBINE ENGINES [OTSENKA KRITERIIA TEKHNICHESKOGO RISKA PRI VYBORE PARAMETROV RABOCHEGO PROTSESSA AVIATSIONNOGO GTD]
A. N. KOVARTSEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 56-59. In Russian.
Copyright

The use of a criterion based on the concept of technical risk as a measure of the reliability of gas turbine designs is discussed. An analysis of the technical risk criterion indicates that the initial data distribution law does not have a significant effect on the values of the design parameters minimizing the technical risk. The technical risk is largely determined by the selected design strategy involving the selection of parameters defined in the technical specification and the assignment of limiting values to these parameters. V.L.

A90-14571
THE PRINCIPLE OF JET ENGINE THRUST GENERATION [O PRINTSIPE SOZDANIIA TIAGI REAKTIVNOGO DVIGATELIA]
V. D. ZAKHAROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 60-63. In Russian.
Copyright

The three-body concept, the principle of thrust generation, and the corresponding model of two opposite flows in a jet engine are examined in a system of coordinates tied to the stationary air medium in which the flight of the jet aircraft takes place. The general theoretical concepts examined in this paper provide the basis for a physical theory describing the mechanism of body acceleration, thrust generation, and operation of a jet engine. V.L.

A90-14572
EFFECT OF PRESSURE ON THE ELECTROPHYSICAL PROPERTIES OF TWO-PHASE FLOWS IN NOZZLES [VLIIANIE DAVLENIIA NA ELEKTROFIZICHESKIE SVOISTVA DVUKHFAZNYKH POTOKOV PRI TECHENII V SOPLAKH]
M. M. LAMPASOV, G. B. ODINOKOVA, and A. S. CHERENKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 63-66. In Russian.
Copyright

The influence of nonequilibrium effects on the electrical conductivity of combustion products is examined in the context of a physicomathematical model of flow of a two-phase polydisperse reacting mixture in a nozzle. It is shown that the electrophysical properties of combustion products are significantly (up to an order

of magnitude) affected by the temperature lag of condensed particles. V.L.

A90-14583
GENERALIZED RELATIONS FOR ESTIMATING THE EFFICIENCY AND BASIC DIMENSIONS OF SCREW PUMPS AND HYDRAULIC TURBINES OF PUMP UNITS [OBOBSHCHENNYE ZAVISIMOSTI DLIA OTSENKI EKONOMICHNOSTI I OSNOVNYKH RAZMEROV SHNEKOVYKH NASOSOV I GIDRAVLICHESKIKH TURBIN NASOSNYKH AGREGATOV]
B. I. BOROVSKII, N. I. KRAVCHIK, and L. A. SOROKINA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 90-92. In Russian. refs
Copyright

The energy and geometrical parameters of screw pumps and hydraulic turbines can be calculated using the available computer software. In evaluating various design versions of powerplants, it is recommended that detailed calculation of pumps be avoided. This is possible if generalized relations are available for the unknown parameters. Here, generalized relations for the efficiency and basic dimensions of screw pumps and hydraulic turbines are derived using results of a computer experiment. V.L.

A90-14586
EFFECT OF THE RADIAL CLEARANCE ON THE EFFICIENCY OF A PARTIAL MICROTURBINE [VLIIANIE RADIAL'NOGO ZAZORA NA EFFEKTIVNOST' PARTSIAL'NOI MIKROTURBINY]
B. A. KRYLOV and S. A. GUSAROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 96-98. In Russian.
Copyright

Results of an experimental study of the effect of the radial clearance on the efficiency of partial microturbines with a shroudless rotor are reported. With reference to results obtained for radial clearances of 0.1, 0.3, 0.5, and 1.0 mm and axial clearances of 0.1 and 1.0 mm, it is shown that the effect of the radial clearance on the turbine efficiency significantly increases with the decreasing partial admission ratio and increasing axial clearance. An analysis of the results obtained indicates that high-efficiency partial microturbines can be designed provided that the radial and axial clearances are sufficiently small. V.L.

A90-14589
OPERATION OF A COMPRESSOR WITH INTERMEDIATE AIR BLEED [RABOTA KOMPRESSORA S PROMEZHUTOCHNYM PEREPUSKOM VOZDUKHA]
E. D. STEN'KIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 103, 104. In Russian.
Copyright

In the case of compressor operation under off-design conditions, with rpm lower than normal, the first stages are loaded while the last stages are unloaded. In order to reduce the range of angle of attack change, controlled air bleed is introduced after the middle stages, which increases the efficiency of the stages and reduces the power required for the engine start-up. Here, the characteristics of compressor operation with intermediate air bleed are investigated analytically, with particular attention given to the relationship between the shift of the head lines on the compressor characteristic and the amount of air bleed. V.L.

A90-14590
EFFECT OF THE ANGLE OF ATTACK ON THE EFFICIENCY AND THRUST RATIO OF AXIAL-FLOW MICROTURBINES WITH FULL ADMISSION [VLIIANIE UGLA ATAKI NA EKONOMICHNOST' I STEPEN' REAKTIVNOSTI OSEVYKH MIKROTURBIN S POLNYM VPUSKOM]
N. T. TIKHONOV and E. E. PFAIFLE Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 104-106. In Russian.
Copyright

The effect of the angle of attack on the efficiency and thrust ratio of axial-flow microturbines was investigated experimentally for angles of attack varying from -16 to +13 deg using eight different rotors. It is shown that there exists an optimal range of angles of attack for each value of Yt=u/c1s. Thus, for Yt=0.3, this range is from -4 to +2 deg. An increase in the angle of attack by 2 deg (i.e., to +4 deg) leads to a 6.8-percent decrease in efficiency; a decrease by 2 deg from the optimal range (i.e., to -6 deg) leads to a 3.5-percent decrease in efficiency. As Yt decreases, the effect of the angle of attack on efficiency becomes less pronounced and remains constant for Yt=0.1. V.L.

A90-14591
CLASSIFICATION OF METHODS FOR ELIMINATING SURGING IN GAS TURBINE ENGINES [KLASSIFIKATSIIA METODOV LIKVIDATSII POMPAZHA GTD]
M. M. SHAKIR'IANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 106-109. In Russian. refs
Copyright

The available methods and devices for eliminating surge phenomena in gas turbine engines are reviewed. In particular, the groups of methods discussed include: (1) complete fuel cutoff; (2) simultaneous manipulation of several powerplant controls; (3) sequential manipulation of powerplant controls; and (4) control of the hot flow path components. The advantages and disadvantages of the methods in each of the above groups and their applications are briefly discussed. V.L.

A90-14614#
EXHAUST EMISSION PERFORMANCE OF A VAPORIZER TUBE COMBUSTOR AS COMPARED WITH A SINGLE TUBE COMBUSTOR
HUIYING LI, LING LIU, MING TANG, HONGJI WANG, ERPING WU (Northwestern Polytechnical University, Xian, People's Republic of China) et al. Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 7, Oct. 1989, p. 447-455. In Chinese, with abstract in English. refs

The control of exhaust emissions is an important problem in the design and development of modern gas turbine combustors. The exhaust emissions of a vaporizer tube combustor and a single tube combustor were measured using a combustion test setup, and the results show that the former is much better than the latter. There is no exponential increase of NO(x) with increasing T3-asterisk, and the increase of NO(x) slows down with increasing T3-asterisk. NO(x) emissions in the vaporizer tube combustor increases more slowly than those in the single tube combustor when inlet air temperature T2-asterisk and pressure P2-asterisk rise. There is an average increase of 10 percent in NO(x) emission when Ga is reduced by 40 percent, and in the single tube combustor a large increase in NO(x) occurs when Ga is reduced. C.D.

A90-15388
LARGE-EDDY SIMULATIONS OF PRESSURE OSCILLATIONS AND COMBUSTION INSTABILITY IN A RAMJET
WEN-HUEI JOU (Boeing Co., Seattle, WA) and SURESH MENON (Flow Research, Inc., Kent, WA) IN: Heat Transfer and Fluid Mechanics Institute, 31st, Sacramento, CA, June 1, 2, 1989, Proceedings. Sacramento, CA, California State University, 1989, p. 1-14. refs
(Contract N00019-88-C-0290)
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An evaluation is made of the development status of the large-eddy simulation (LES) technique's applications to unsteady flows in ramjet combustors. The primary current limitation of LES is the lack of three-dimensional dynamics; at present, only axisymmetric flows are considered. In addition, the inlet diffuser shock is not included in the existing model, and the inflow boundary conditions do not correspond to any plausible acoustic shock impedance. Finally, the modeling of subgrid-scale turbulence is thus far rather limited. O.C.

A90-15390
AN INVESTIGATION INTO THE INTERNAL HEAT TRANSFER CHARACTERISTICS OF A THERMALLY ANTI-ICED AERO-ENGINE INTAKE LIPSKIN
S. J. RILEY (Rolls-Royce, PLC, Derby, England) and E. H. JAMES

(Loughborough University of Technology, England) IN: Heat Transfer and Fluid Mechanics Institute, 31st, Sacramento, CA, June 1, 2, 1989, Proceedings. Sacramento, CA, California State University, 1989, p. 59-76. refs
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Thermal anti-icing systems are commonly used to prevent potentially hazardous ice accretion on aircraft leading edges. To optimize such a system requires accurate modeling techniques, and to improve existing methods, investigations have been made into the heat transfer characteristics of a typical aero-engine intake fitted with a jet impingement hot air anti-icing system. As part of this research, a series of tests was carried out in a sea level wind tunnel using an instrumented full-scale model intake section to provide data for the re-definition of internal heat transfer characteristics. An expression for the internal heat transfer is derived. Author

A90-16001#
APPLIED TECHNOLOGY IN GAS TURBINE AIRCRAFT ENGINE DEVELOPMENT
THOMAS C. PAUL (GE Aircraft Engines, Lynn, MA) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 333-340.

Current development efforts at GE Aircraft Engines are reviewed, including: (1) large structural castings to simplify components, (2) polymeric composites for light weight and strength, (3) improved methods for determining heat transfer, and (4) coatings and surface treatments to prolong component life. Particular attention is given to the implementation of these technologies in the T700 and F404 engines. B.J.

A90-16002#
XG40 - ROLLS-ROYCE ADVANCED FIGHTER ENGINE DEMONSTRATOR
G. M. LEWIS (Rolls-Royce, PLC, Bristol, England) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 341-352. Research supported by Ministry of Defence Procurement Executive.

Commenced in 1982, the XG40 program is central to the demonstration of Rolls-Royce technology appropriate to the requirements of the advanced combat engine for mid 1990's operation. At the same time, the technology in scaled form is viewed as having wider application than for the advanced combat engine alone. To meet the multi-role requirements of advanced twin and single-engined fighters, the combat engine must be designed to give enhanced dry thrust, retain good dry specific fuel consumption and reduce reheated fuel consumption compared with current fighter engines. A thrust/weight ratio of 10 : 1 is targeted and at the same time requirements for operating cost, reliability and durability are stringent. Advanced materials, manufacturing technology and design of structures have been incorporated to enable the required levels of reliability, durability, component cost and weight to be demonstrated. The engine is in the 90/95 kN nominal Sea Level Static Combat thrust class. Author

A90-16004#
ADVANCED COMBUSTOR LINER COOLING TECHNOLOGY FOR GAS TURBINES
ASPI R. WADIA (General Electric Co., Cincinnati, OH) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 363-380. refs

This paper briefly reviews some of the work on advanced liner cooling techniques - specifically laminated porous wall cooling, angled-multihole (effusion) cooling and composite metal matrix liner cooling. The concept definition, heat transfer design procedure and design problems including key materials and fabrication considerations associated with each basic concept will be reviewed. Published rig and engine experience of aircraft engine manufacturers and research organizations will be cited. Some logical extensions of the current liner cooling schemes are suggested for future applications. Author

A90-16005#
SELECTION OF A SUITABLE COMBUSTION SYSTEM FOR A SMALL GAS TURBINE ENGINE
P. ARUNACHALAM (Hindustan Aeronautics, Ltd., Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 381-395. refs

Experimental studies on a straight and a reverse flow annular combustion chamber to select a suitable combustion system for a small gas turbine engine are presented. One straight flow annular combustor with simplex fuel injector and three sector models of the reverse flow annular combustor with simplex, airblast and vaporizer type of fuel injectors were fabricated and tested, retaining the same maximum outer casing diameter. The paper presents the basic design procedure, the three types of fuel injection system and the performance comparison of these models. An attempt has been made to develop a correlation to compare the performance of the models. It has been concluded that with the available data, for small gas turbine engines, reverse flow annular combustor with vaporizer is the best from overall considerations. Author

A90-16006#
GAS TURBINE ENGINE COMPONENT DEVELOPMENT - AN INTEGRATED APPROACH
WILLEM JANSEN (Northern Research and Engineering Corp., Woburn, MA) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 397-411. refs

Computer-aided engineering methods have made a significant impact in the design technologies of advanced machinery. These methods have been applied in several areas such as aerodynamic and fluid dynamic theory for high efficiency, stress and vibration theory for reliability and manufacturing strategies to produce machined components at low cost and with short time schedules. The integration of these various design technologies offer the opportunity for even greater productivity in the engineering design and manufacturing process. This paper addresses the application of various engineering disciplines to the demand of producing a reliable, efficient design and the subsequent manufacture of components with short lead times through the interaction of these computer-aided engineering technologies. The concept is further illustrated by sample cases for a centrifugal compressor and a gas turbine. Author

A90-16007#
DESIGNING TURBINE BLADES FOR FATIGUE AND CREEP
BRUNO DAMBRINE and JEAN PIERRE MASCARELL (SNECMA, Paris, France) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 413-429. refs

Various methods and tools adopted at SNECMA for modeling the thermal fatigue and creep phenomena of turbine blades are described. A novel life prediction method is described and analyses are presented of the constitutive equations of the material for modeling the viscoelastic effects under cyclic loading; the structure of a finite element program used to simulate cyclic viscoplastic behavior; and the continuum damage method. The proposed theoretical approach has been validated experimentally. Finally, the exploitation of single crystal alloys is considered. B.J.

A90-16008#
PHOTOELASTIC INVESTIGATION OF TURBINE ROTOR BLADE SHROUDS
U. CHANDRASEKHAR, D. GURURAJ, K. RAMACHANDRA, and R. PADMANABHAN (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 431-438.

This paper deals with the photoelastic stress analysis carried out to investigate the premature failure of low pressure turbine rotor blade shrouds of an experimental gas turbine. Stress distribution at the shroud aerofoil interface was studied for the original rectangular shroud geometry by stress-freezing the photoelastic model blades under rotating conditions. The combined influence of taper shroud geometry and larger fillet radius in mitigating the shroud stress is studied by the three-dimensional

photoelastic technique and an optimized shroud geometry subject to the stress requirements of blade material is suggested.
Author

A90-16009#
SQUEEZE FILM DAMPING FOR AIRCRAFT GAS TURBINES
R. W. SHENDE and S. K. SANE (Indian Institute of Technology, Bombay, India) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 439-456. refs

Modern aircraft gas turbine engines depend heavily on squeeze film damper supports at the bearings for abatement of vibrations caused by a number of probable excitation sources. This design ultimately results in light-weight construction together with higher efficiency and reliability of engines. Many investigations have been reported during past two decades concerning the functioning of the squeeze film damper, which is simple in construction yet complex in behavior with its nonlinearity and multiplicity of variables. These are reviewed in this article to throw light on the considerations involved in the design of rotor-bearing-casing systems incorporating squeeze film dampers. Author

A90-16010#
INTEGRATED APPROACH TO DESIGN AND MANUFACTURE OF GAS TURBINE COMPONENTS BASED ON GROUP THEORY
M. JAWAHARLAL and A. ARUL RAJ (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 457-465. refs

This paper deals with a new method that provides an integrated approach to design and manufacture of gas turbine components by using the group theory and customizing standard computer-aided design and manufacturing system. With this approach, time-consuming and iterative design procedure and process-planning are automated and become more efficient. Due to the intricate and diverse nature of gas turbine components, grouping them is not easy as in other industries. A possible way of grouping the gas turbine components based on design and manufacturing attributes on a broad basis is presented. A case study of high pressure turbine disk is included with illustrations for design and process-planning of this component. The proposed system is implemented on a personal computer and offers an alternate solution to sophisticated and expensive mainframe-based system. Author

A90-16049
DYNAMICS OF AVIATION GAS TURBINE ENGINES [DINAMIKA AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEI]
GEORGII V. DOBRIANSKII and TAT'IANA S. MART'IANOVA Moscow, Izdatel'stvo Mashinostroenie, 1989, 240 p. In Russian. refs
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Results of studies concerned with the development of mathematical models of gas turbine engines of various types are summarized. The construction of mathematical models of various levels, including elementary, simplified nonlinear, linear and regression models, is discussed. The dynamic characteristics of gas turbine engines are examined. Attention is also given to the characteristics of nonstationary processes (near the stationary regimes), startup, accelerating capacity, thrust augmentation, and operation in some emergency situations. V.L.

A90-16373#
EFFECT OF ENVIRONMENTAL PARTICLES ON A RADIAL COMPRESSOR
W. TABAKOFF and A. HAMED (Cincinnati, University, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Nov.-Dec. 1989, p. 731-737. Research sponsored by DOE. Previously cited in issue 07, p. 951, Accession no. A88-22268. refs
Copyright

N90-11737# National Aerospace Lab., Tokyo (Japan). Aeroengine Div.
EFFECTS OF A HEAT CYCLE ON MATERIAL STRENGTH
TAMEHARU IKEDA Jan. 1987 14 p In JAPANESE
(NAL-TM-562; ISSN-0452-2982; JTN-88-80057) Avail: NTIS HC A03/MF A01

Pyrogenic components of thermal engines that are frequently started and stopped, such as in aircraft jet engines, are repetitively subjected to heating and cooling due to engine starts and stops. Therefore, the non-steady thermal stresses that result must be taken into consideration. These thermal stress are caused by many compounded conditions such as changes in heating and cooling speeds, heat transfer, thermal conduction, thermal expansion, specific heat and the shapes of parts and members. Heating and cooling tests of T3 treated sheets of high-tension aluminum alloy 2024S and cast iron are discussed. The cast iron test was conducted by repeated heating and cooling to study cracking and propagation of high-temperature parts and materials. The tests were conducted in a wind tunnel for thermal shock tests.
NASDA

N90-11738*# Lockheed Aeronautical Systems Co., Marietta, GA.
PROPFAN TEST ASSESSMENT (PTA): FLIGHT TEST REPORT
B. H. LITTLE, H. W. BARTEL, N. N. REDDY, G. SWIFT, C. C. WITHERS, and P. C. BROWN (United Technologies Corp., Windsor Locks, CT.) Apr. 1989 276 p
(Contract NAS3-24339)
(NASA-CR-182278; NAS 1.26:182278; LG89ER0026) Avail: NTIS HC A13/MF A02 CSCL 21/5

The Propfan Test Assessment (PTA) aircraft was flown to obtain glade stress and noise data for a 2.74m (9 ft.) diameter single rotation propfan. Tests were performed at Mach numbers to 0.85 and altitudes to 12,192m (40,000 ft.). The propfan was well-behaved structurally over the entire flight envelope, demonstrating that the blade design technology was completely adequate. Noise data were characterized by strong signals at blade passage frequency and up to 10 harmonics. Cabin noise was not so high as to preclude attainment of comfortable levels with suitable wall treatment. Community noise was not excessive. Author

N90-11739*# Lockheed Aeronautical Systems Co., Marietta, GA.
PROPFAN TEST ASSESSMENT (PTA) Final Report
B. H. LITTLE, D. T. POLAND, H. W. BARTEL, C. C. WITHERS, and P. C. BROWN (United Technologies Corp., Windsor Locks, CT.) Jul. 1989 676 p
(Contract NAS3-24339)
(NASA-CR-185138; NAS 1.26:185138; LG89ER0064) Avail: NTIS HC A99/MF A04 CSCL 21/5

The objectives of the Propfan Test Assessment (PTA) Program were to validate in flight the structural integrity of large-scale propfan blades and to measure noise characteristics of the propfan in both near and far fields. All program objectives were met or exceeded, on schedule and under budget. A Gulfstream Aerospace Corporation GII aircraft was modified to provide a testbed for the 2.74m (9 ft) diameter Hamilton Standard SR-7 propfan which was driven by a 4475 kw (600 shp) turboshaft engine mounted on the left-hand wing of the aircraft. Flight research tests were performed for 20 combinations of speed and altitude within a flight envelope that extended to Mach numbers of 0.85 and altitudes of 12,192m (40,000 ft). Propfan blade stress, near-field noise on aircraft surfaces, and cabin noise were recorded. Primary variables were propfan power and tip speed, and the nacelle tilt angle. Extensive low altitude far-field noise tests were made to measure flyover and sideline noise and the lateral attenuation of noise. In coopertion with the FAA, tests were also made of flyover noise for the aircraft at 6100m (20,000 ft) and 10,668m (35,000 ft). A final series of tests were flown to evaluate an advanced cabin wall noise treatment that was produced under a separate program by NASA-Langley Research Center. Author

N90-11740*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STOVL PROPULSION SYSTEM VOLUME DYNAMICS APPROXIMATIONS
COLIN K. DRUMMOND 1989 11 p Presented at the 1989 Winter Annual Meeting, San Francisco, CA, 10-15 Dec. 1989, sponsored by ASME
(NASA-TM-102397; E-5147; NAS 1.15:102397) Avail: NTIS HC A03/MF A01 CSCL 21/5

Two approaches to modeling turbofan engine component volume dynamics are explored and compared with a view toward application to real-time simulation of short take-off vertical landing (STOVL) aircraft propulsion systems. The first (and most popular) approach considers only heat and mass balances; the second approach includes a momentum balance and substitutes the heat equation with a complete energy balance. Results for a practical test case are presented and discussed. Author

N90-11741*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
MEASUREMENT EFFECTS ON THE CALCULATION OF IN-FLIGHT THRUST FOR AN F404 TURBOFAN ENGINE
TIMOTHY R. CONNERS Sep. 1989 24 p Presented at the AIAA Joint Propulsion Conference, Monterey, CA, 10-14 Jul. 1989 Previously announced in IAA as A89-46777
(NASA-TM-4140; H-1556; NAS 1.15:4140; AIAA-89-2364) Avail: NTIS HC A03/MF A01 CSCL 21/5

A study was performed that investigates parameter measurement effects on calculated in-flight thrust for the General Electric F404-GE-400 afterburning turbofan engine which powered the X-29A forward-swept wing research aircraft. Net-thrust uncertainty and influence coefficients were calculated and are presented. Six flight conditions were analyzed at five engine power settings each. Results were obtained using the mass flow-temperature and area-pressure thrust calculation methods, both based on the commonly used gas generator technique. Thrust uncertainty was determined using a common procedure based on the use of measurement uncertainty and influence coefficients. The effects of data nonlinearity on the uncertainty calculation procedure were studied and results are presented. The advantages and disadvantages of using this particular uncertainty procedure are discussed. A brief description of the thrust-calculation technique along with the uncertainty calculation procedure is included.
Author

N90-11743# Dayton Univ., OH.
COMPUTATION OF RAMJET INTERNAL FLOWFIELDS Final Report, Jan. 1986 - Dec. 1988
JAMES N. SCOTT, WILBUR L. HANKEY, and THOMAS P. GIELDA May 1989 91 p
(Contract F33615-86-C-2615)
(AD-A212001; WRDC-TR-89-2025) Avail: NTIS HC A05/MF A01 CSCL 21/1

This document reports on the computation of Ramjet Internal Flowfields. It is divided into two sections, i.e., subsonic and supersonic combustion. To numerically simulate subsonic combustion, the time-dependent Navier-Stokes equations are used with additional species equations incorporated to model hydrocarbon-air combustion. To compute supersonic combustion, the parabolized Navier-Stokes equations are utilized (PNS) with species equations to simulate hydrogen-air combustions. Model cases are computed and compared with limited experimental data. GRA

N90-11745# Aeronautical Research Labs., Melbourne (Australia).
AN OPEN-LOOP TRANSIENT THERMODYNAMIC MODEL OF THE COUGUAR TURBOJET
P. C. FRITH Apr. 1989 69 p
(AD-A211774; ARL-PROP-TM-457; DODA-AR-005-582) Avail: NTIS HC A04/MF A01 CSCL 21/5

An open-loop, transient, thermodynamic model of the single-spool Couguar turbojet was developed for use in both fault diagnosis and engine control research work. The model is based on TURBOTRANS, a generic engine modeling computer program, and it was calibrated against test cell measurements of the steady-state running line. The model provided good predictions of a series of accelerations and decelerations over the operating range of the turbojet. Estimates of the steady-states gains and time constants, across the speed range of the engine, are also presented. GRA

N90-11746# Rolls-Royce Ltd., Derby (England). Product Support Dept.
THE RB199: AN IN-SERVICE SUCCESS
K. FLANDERS 13 Apr. 1987 7 p Presented at the SBAC Symposium (Multi Purpose Combat Aircraft), Belgrade, Yugoslavia, 13-14 Apr. 1987
(PNR90544; ETN-89-95542) Copyright Avail: NTIS HC A02/MF A01

The performance of the RB199 engine is assessed. The modular design, on-condition maintenance and flexibility of the engine are described. There is no fixed time between overhauls on these engines. Repairs are carried out only to remedy a diagnosed fault. The reliability rates nonetheless compare favorably with any other military engine. The maintenance record for these engines, which have completed over 500,000 flying hours in Tornado aircraft, is fully documented. ESA

N90-11747# Rolls-Royce Ltd., Derby (England).
ADVANCED TECHNOLOGY IN MILITARY GAS TURBINE DESIGN AND MANUFACTURE
B. J. QUINN 13 Apr. 1987 9 p Presented at the SBAC Symposium (Multi Purpose Combat Aircraft), Belgrade, Yugoslavia, 13-14 Apr. 1987
(PNR90545; ETN-89-95543) Copyright Avail: NTIS HC A02/MF A01

The interaction of design and manufacturing technology in achieving high engine and component efficiency is described. The use of high precision three dimensional aerodynamic design and manufacturing methods is described. The goal of the research, to obtain a high thrust/weight ratio in combat, but a low fuel consumption while patrolling to minimize aircraft size, is outlined. This goal is achieved by using high flame temperatures, medium bypass ratios, high overall pressure ratios and good component efficiencies. ESA

N90-11748# Rolls-Royce Ltd., Derby (England). Controls and Electronics Group.
ENGINE CONTROLS FOR THE 1990'S
V. A. FISHER 13 Apr. 1987 6 p Presented at the SBAC (Multi Purpose Combat Aircraft), Belgrade, Yugoslavia, 13-14, Apr. 1987
(PNR90546; ETN-89-95544) Copyright Avail: NTIS HC A02/MF A01

The development of controls with increased emphasis on minimum hydromechanics and use of digital techniques is discussed. Changes in the way that designs are specified, and subsequent changes in maintenance attitudes are necessary, to fully exploit these more sophisticated systems. The concept of the engine control systems for the 1990s is described. Arguments of how integrity, reliability and control system performance will be obtained are presented. ESA

N90-11749# Rolls-Royce Ltd., Derby (England).
FUTURE MILITARY POWERPLANTS
W. J. LEWIS 21 May 1988 20 p Presented at the I. Mech. E. Seminar for 21st Century Aero-Engine Design, 21 May 1988
(PNR90554; ETN-89-95547) Copyright Avail: NTIS HC A03/MF A01

The importance of fighter aircraft engine development as the leading edge of technological development is outlined. It is expected that fighter engines of the next century will continue to follow the trends already established. Thrust over weight ratios will increase and fuel consumption and costs will be reduced. The use of composites will become more widespread. It is likely

that development of new materials, manufacturing processes, and aerodynamic and thermodynamic techniques will be the major areas of technological development. ESA

N90-11750# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Dept.
COATINGS FOR GAS TURBINE COMPRESSORS
H. J. KOLKMAN 8 Jul. 1988 10 p Presented at the Materials Developments in Turbomachinery Design Conference, Cambridge, United Kingdom, 12-14 Sep. 1988 Sponsored in part by the Royal Netherlands Air Force
(NLR-MP-88045-U; ETN-89-95057) Avail: NTIS HC A02/MF A01

A number of compressor coatings with supposedly high erosion resistance are investigated. Both the erosion and corrosion resistances of these coatings are investigated under simulated service conditions in the NLR (National Aerospace Laboratory) compressor test rig. Uncoated helicopter jet engine compressors have experienced severe pitting problems in the Western European environment. Moisture absorbed by hydroscopic salts, acidified by air pollutants such as sulfur dioxide and nitrogen dioxide, caused pitting corrosion (manifested by the presence of metal ions). Magnesium chloride, a natural marine salt, supplies the chloride ions which attack the protective oxide layer of stainless steels. It is concluded that the ideal compressor coating is not yet available. ESA

N90-12600 Iowa Univ., Iowa City.
STAGE EFFECTS ON STALLING AND RECOVERY OF A HIGH-SPEED 10-STAGE AXIAL-FLOW COMPRESSOR Ph.D. Thesis
WILLIAM WARD COPENHAVER 1988 400 p
Avail: Univ. Microfilms Order No. DA8909139

Results of a high speed 10-stage axial flow compressor test involving overall compressor and individual stage performance while stalling and operating in quasi-steady rotating stall are described. Test procedures and data acquisition methods used to obtain the dynamic stalling and quasi-steady in-stall data are explained. Unstalled and in-stall time averaged data obtained from the compressor operating at five different shaft speeds and one off-schedule variable vane condition are presented. The effects of compressor speed and variable geometry on overall compressor in-stall pressure rise and hysteresis extent are illustrated through the use of quasi-steady stage temperature rise and pressure rise characteristics. The results indicate that individual stage performance during overall compressor rotating stall operation varies considerably throughout the length of the compressor. Time resolved in-stall data acquired at two different shaft speeds are presented in support of the notion that stage operation varies significantly from entrance to exit of the compressor. Both time-averaged and time-resolved individual stage results suggest that stage matching is important, not only for unstalled performance but also for in-stall performance and recoverability from stall. The measured high speed 10-stage test compressor individual stage pressure and temperature characteristics were input into a stage-by-stage dynamic compressor performance model. The analytical model had been previously validated for the prediction of low-speed compressor stalling and in-stall performance. Dynamic pressures measured during stalling of the high speed 10-stage test compressor are compared during stalling of the high speed 10-stage test compressor are compared with analytical model results. The comparison of the model results and with analytical model results. The comparison of the model results and the measured pressures provided the additional validation necessary to demonstrate the model's ability to predict high speed multistage compressor stalling and in-stall performance. Dissert. Abstr.

N90-12603# Rolls-Royce Ltd., Derby (England).
A VISION OF THE FUTURE: THE NEW ENGINE TECHNOLOGY
P. C. RUFFLES 21 Aug. 1988 9 p Presented at the Financial Times Conference on Commercial Aviation to the End of the Century, London, England, 31 Aug. 1988
(PNR90566; ETN-89-95551) Copyright Avail: NTIS HC A02/MF A01

Predictions of future trends in engine design and technology are presented. These include reduction of fuel consumption with further improvement to current high bypass ratio engines and later by application of ultrahigh bypass ratio technology. Aircraft and engines are predicted as becoming larger. Large twin engine aircraft will require ever larger thrusts. The need for new materials in order to develop a light weight ultrahigh bypass ratio engine is stressed. Computer integration of design and manufacture processes is predicted for the lowering of development and production costs of such an engine. ESA

N90-12604# Rolls-Royce Ltd., Derby (England).
DESIGNING FOR RELIABLE AND LOW MAINTENANCE COST AERO ENGINES
S. P. Q. BYWORTH 15 Dec. 1988 25 p Presented at the Frank Radcliffe Bequest Seminar, 9 Dec. 1988
(PNR90570; MISS-2144; ETN-89-95553) Copyright Avail: NTIS HC A03/MF A01

The major engine factors influencing airline operating costs and the balance the engine designer has to make between the often conflicting requirements of improvements in fuel consumption, initial cost and maintenance costs are briefly reviewed. Operating costs are broken down, fuel burn trends are analyzed, and comparisons in operating costs are made between different Rolls Royce turbojet and turbofan engines. Modularity is investigated as a means of lowering costs, and typical maintenance cost forecasts are made. ESA

N90-12605# Rolls-Royce Ltd., Derby (England).
THE NEXT GENERATION SUPERSONIC TRANSPORT ENGINE: CRITICAL ISSUES
B. W. LOWRIE, R. M. DENNING, and P. C. GUPTA 19 Apr. 1989 25 p Presented at the Royal Aeronautical Society Symposium on Aerodynamics Design for Supersonic Flight, London, England, 19 Apr. 1988
(PNR90576; E/BLO/163; ETN-89-95556) Copyright Avail: NTIS HC A03/MF A01

The design of a successor to the Concorde with a longhaul range of 5500 nautical miles is discussed. The ability of the engine and airframe to produce this range economically is briefly examined. Some offdesign implications of choice of cruise Mach number on matching and subsonic performance are outlined. Environmental requirements which can be controlled or influenced by engine design are discussed and the key issues noted. Consequent requirements for engine cycle variability are defined and two possibilities assessed. ESA

N90-12606# Rolls-Royce Ltd., Derby (England). Civil Powerplant Technology Engineering.
RE-ENGINE WITH THE ROLLS-ROYCE TAY 670, THE ROUTE TO SIGNIFICANT NOISE REDUCTION
V. M. SZEWCZYK 31 Jan. 1989 19 p Presented at the Avmark Noise Conference, Washington, DC, 31 Jan. 1989
(PNR90585; ETN-89-95560) Copyright Avail: NTIS HC A03/MF A01

The use of the Tay 670 engine to re-engine B 737-200, B 727-200 and DC 9 aircraft is described. The Tay engine has low jet velocities consistent with low noise production. Studies predicting that older aircraft re-engined with the Tay 670 will be competitive on noise with modern stage three turbofan powered aircraft are shown. The necessity for such engine changes due to ever increasing noise restrictions is described. ESA

N90-12608# Rolls-Royce Ltd., Derby (England). Materials and Mechanical Technology Dept.
THE ROLE OF COMPONENT TESTING
G. ASQUITH 26 Apr. 1989 14 p Presented at the 68th AGARD Structures and Materials Panel Meeting, Ottawa, Ontario, 26 Apr. 1989
(PNR90589; ETN-89-95562) Copyright Avail: NTIS HC A03/MF A01

The importance of component testing in ensuring that design and life goals of engines are met is addressed. The integration of

component testing and material data generation into a material data bank is described. The techniques of stress and fracture mechanics analysis, crack monitoring, metallography and probabilistic approaches are used in establishing this data bank. The use of data on the material behavior of components in the development of new and improved materials is stressed. ESA

N90-12609# Rolls-Royce Ltd., Derby (England).
FLANGED JOINTS OF AEROENGINES
L. V. LEWIS, H. FESSLER, and T. H. HYDE (Nottingham Univ., England) 4 Sep. 1989 12 p Presented at the 9th International Symposium on Air Breathing Engines, Athens, Greece, 4-9 Sep. 1989
(PNR90594; ETN-89-95565) Copyright Avail: NTIS HC A03/MF A01

The design of a metal-to-metal bolted joint between two aeroengine casings is described. The joint has to achieve structural integrity and perform a sealing function. It must be light and have a small number of bolts. It is shown that present joints often fail to seal, and suffer high cyclic stresses in the bolts and in the flange profiles. A way of pre-loading the joint on assembly is presented. It involves machining a cone angle onto the flange faces, so that a high-intensity line reaction is generated at the inside diameter on assembly. It is shown that perfect sealing can be achieved, and maintained at ratios of axial joint load/assembly bolt load that exceed present practice. Cyclic stresses are reduced to negligible proportions, so that low cycle fatigue is no longer a potential failure mode. It is shown that assembly stresses can be kept within elastic limits with acceptably light flange profiles. ESA

N90-12610# Rolls-Royce Ltd., Derby (England).
MATERIAL REQUIREMENTS FOR FUTURE AEROENGINES
G. E. KIRK 4 Sep. 1989 8 p Presented at the 9th International Symposium on Air Breathing Engines, Athens, Greece, 4-9 Sep. 1989
(PNR90595; ETN-89-95566) Copyright Avail: NTIS HC A02/MF A01

Improvements made in aeroengine technology are summarized. Performance gains, longer engine lives and higher thrust to weight ratio obtained through materials and process technology which made a significant contribution to this progress are outlined. For materials with higher temperature capability, lower cost and increased strength and stiffness in the future is stressed. Planned aeroengine configurations will not be viable without improvements in material properties and manufacturing technology. The developmental potential of titanium and nickel, and that of newer composite materials is outlined in terms of their use in future aeroengines. The problems that must be solved before they can be effectively used are identified. ESA

N90-12611# Rolls-Royce Ltd., Derby (England).
A COMPUTER INTEGRATED APPROACH TO DIMENSIONAL INSPECTION
S. A. LEE, N. TSABOURAKIS, M. RISTIC, and C. B. BESANT 3 Sep. 1989 10 p Presented at the 9th International Symposium on Air Breathing Engines, Athens, Greece, 4-9 Sep. 1988
(PNR90596; ETN-89-95567) Copyright Avail: NTIS HC A02/MF A01

A computer integrated dimensional inspection system supporting contact and noncontact methods of surface digitization is described. An extensive error handling facility enables errors to be found between nominal and actual surfaces. These errors may be presented, for example as contours of error, or be used in a three dimensional best-fitting process which minimizes error between actual and nominal surfaces. The design and development of the system are given in outline with a resume of its use. The system proves to be very powerful in dealing with the inspection of the highly complex forms involved in turbine blading. ESA

N90-12612# Rolls-Royce Ltd., Derby (England).
DYNAMIC TIP CLEARANCE MEASUREMENTS IN AXIAL FLOW COMPRESSORS
C. J. PARRISH 15 Sep. 1989 6 p Presented at the COMADEM 89 International, Birmingham, England, Sep. 1989
(PNR90597; ETN-89-95568) Copyright Avail: NTIS HC A02/MF A01

Techniques used in measurement of tip clearance and the detection of tip rubs between rotor blade tips and rotor path lining in the compressors of jet engines are described. The importance of such measurements in obtaining engine efficiency is stressed. Tip clearance results broken down into closure, surge, and orbit types, are discussed. It is concluded that tip rubs occur during surge with a resultant loss in compressor efficiency. Closures are measured with rotor orbit to obtain the best cold build clearances for maximum compressor efficiency. ESA

N90-12613# Rolls-Royce Ltd., Derby (England).
THE DEVELOPMENT OF A HIGH RESPONSE AERODYNAMIC WEDGE PROBE AND USE ON A HIGH-SPEED RESEARCH COMPRESSOR Ph.D. Thesis - Cranfield Inst. of Technology
S. C. COOK 4 Sep. 1989 14 p Presented at the 9th International Air Breathing Engines, Athens, Greece, 4-9 Sep. 1988 Sponsored by the Ministry of Defence, London, England and the United Kingdom Science and Engineering Research Council
(PNR90598; ETN-89-95569) Copyright Avail: NTIS HC A03/MF A01

A high response aerodynamic wedge probe developed for use in performance testing of high-speed, axial-flow, research compressors and fans is described. The miniature probe incorporates flush-mounted high response silicon piezo-resistive pressure transducers, with both a dynamic and steady state measurement capability. New information on wedge probe aerodynamic sensitivity is given and details of important improvements to an iterative data reduction algorithm, facilitating successful use on dynamic data, are included. An electronic compensation scheme is employed to overcome the inherent temperature sensitivity of the transducers. Using this system, previously unreported transducer output nonlinearities are revealed. The 30 degree included angle wedge probe has a frequency response in excess of 100 kHz. The wedge probe was applied to a highspeed (9 kHz blade passing frequency), single-stage, axial-flow, research compressor at rotor trailing edge. Time resolved rotor wakes were measured using the wedge probe and compared with rotating wake data obtained using a crossed hot wire anemometer probe. The rotor wakes were found to be highly unsteady in terms of both amplitude and spatial location. ESA

N90-12614# Rolls-Royce Ltd., Derby (England).
GAS TURBINE PERFORMANCE ANALYSIS
A. J. B. JACKSON 20 Jun. 1989 74 p Lecture presented at the Warwick Univ. IGDS Course, Warwick, England
(PNR90599; ETN-89-95570) Copyright Avail: NTIS HC A03/MF A01

The present state of gas turbine development is summarized. The history of gas turbine development is reviewed. The component parts of a gas turbine engine and their performance are outlined. Typical gas turbine overall characteristics are discussed, with attention given to power setting, atmospheric temperature, altitude and forward speed. Transient turbine behavior and overall aircraft performance are examined. ESA

N90-12616# Rolls-Royce Ltd., Derby (England). Theoretical Science Group.
BLADING DESIGN FOR MULTI-STORAGE HP COMPRESSOR
P. STOW 13 Mar. 1989 43 p Presented at the AGARD LS167 on Blading Design for Axial Turbomachines, Jun. 1987
(PNR90602; TSG0428; ETN-89-95573) Copyright Avail: NTIS HC A03/MF A01

Computer aided turbomachinery blade design is discussed with the emphasis on the mathematical models needed to account for physical phenomena. The various aspects of a typical blade design system are presented covering through-flow and blade-to-blade analysis. The through-flow aspects such as linked through-flow-blade-to-blade analysis, blade loss models, end-wall boundary layers, secondary flow analysis and spanwise mixing

models are discussed. Blade section design using mixed design and analysis methods is covered. Loss prediction using coupled inviscid boundary layer approaches is carried out. Limitations of the coupled approach are discussed together with the emerging role of Reynolds averaged Navier-Stokes methods aimed at removing these limitations. The need for fully three dimensional methods and their incorporation into the design system are discussed. Areas for future development and application are discussed. ESA

N90-12617*# Hamilton Standard Div., United Aircraft Corp., Windsor Locks, CT.
LARGE-SCALE ADVANCED PROP-FAN (LAP) STATIC ROTOR TEST REPORT
CHARLES L. DEGEORGE, JAY E. TURNBERG, and HARRY S. WAINAUSKI 1987 156 p
(Contract NAS3-23051)
(NASA-CR-180848; NAS 1.26:180848; HSER-116227) Avail: NTIS HC A08/MF A01 CSCL 21/5

Discussed is Static Rotor Testing of the SR-7L Large Scale Advanced Prop-Fan (LAP). The LAP is an advanced 9 foot diameter, 8 bladed propeller designed and built by Hamilton Standard under contract to the NASA Lewis Research Center. The Prop-Fan employs thin swept blades to provide efficient propulsion at flight speeds up to Mach .85. Static Testing was conducted on a 10,000 HP whirl rig at Wright Patterson Air Force Base. The test objectives were to investigate the Prop-Fan static aerodynamic and structural dynamic performance, determine the blade steady state stressers and deflections and to measure steady and unsteady pressures on the SR-7L blade surface. The measured performance of the LAP correlated well with analytical predictions at blade pitch angles below 30 deg. A stall buffet phenomenon was observed at blade pitch angles above 30 deg. This phenomenon manifested itself by elevated blade vibratory stress levels and lower than expected thrust produced and power absorbed by the Prop-Fan for a given speed and blade angle. Author

N90-12618*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
REAL-TIME SIMULATION OF AN F110/STOVL TURBOFAN ENGINE
COLIN K. DRUMMOND and PETER J. OUZTS Nov. 1989 24 p Presented at the Central/Northeastern ADIUS Conference, Cleveland, OH, 16-17 Oct. 1989; sponsored by Applied Dynamics International
(NASA-TM-102409; E-5162; NAS 1.15:102409) Avail: NTIS HC A03/MF A01 CSCL 21/5

A traditional F110-type turbofan engine model was extended to include a ventral nozzle and two thrust-augmenting ejectors for Short Take-Off Vertical Landing (STOVL) aircraft applications. Development of the real-time F110/STOVL simulation required special attention to the modeling approach to component performance maps, the low pressure turbine exit mixing region, and the tailpipe dynamic approximation. Simulation validation derives by comparing output from the ADSIM simulation with the output for a validated F110/STOVL General Electric Aircraft Engines FORTRAN deck. General Electric substantiated basic engine component characteristics through factory testing and full scale ejector data. Author

N90-12619# Royal Aerospace Establishment, Farnborough (England).
PRELIMINARY EXPERIENCE WITH HIGH RESPONSE PRESSURE MEASUREMENTS IN A MULTISTAGE, HIGH SPEED COMPRESSOR
M. A. CHERRETT and J. D. BRYCE 24 May 1988 26 p Presented at the 9th International Symposium on Measuring Techniques for Transonic and Supersonic Flows in Cascades and Turbomachines, Oxford, England, 21-22 Mar. 1988
(RAE-TM-P-1141; BR108489; ETN-89-94999) Copyright Avail: NTIS HC A03/MF A01

The unsteady aerodynamic phenomena within high speed axial turbomachines is investigated. A measuring system with a frequency bandwidth of 100 to 150 kHz is applied. Experiments to commission and prove a realtime digital data acquisition system are detailed. The strategy adopted for data analysis is described, particularly the facility to lock the data capture process to the rotating frame of the machine to carry out phase locked analysis on-line. Miniature high frequency response pressure transducers are used to measure the unsteady total and wall static pressures within a high speed axial core compressor. Successful protection of the transducer diaphragm is achieved. Experiments regarding the use of such transducers in this environment is described. ESA

N90-12620# Minnesota Univ., Minneapolis.
STUDIES OF GAS TURBINE HEAT TRANSFER AIRFOIL SURFACES AND END-WALL COOLING EFFECTS Final Report, 1 Mar. 1986 - 28 Feb. 1989
E. R. ECKERT, R. J. GOLDSTEIN, S. V. PATANKAR, and T. W. SIMON Jul. 1989 90 p
(Contract F49620-85-C-0049)
(AD-A212451; AFOSR-89-1225TR) Avail: NTIS HC A05/MF A01 CSCL 21/5

Understanding and prediction of the heat transfer in a turbine is dependent first on understanding the complex three-dimensional flow that occurs around a blade. In a turbine passage there are complex (interacting) vortices, significant variation in surface curvature, flow separation, transition from laminar to turbulent flow and perhaps relaminarization, and the influence of high turbulence level in the free stream flow. Heat or mass transfer measurements, aside from providing the needed design information, can also tells a great deal about the flow. The transport of heat or mass was used to detect characteristics of flow which were not readily detectable by other means. Modeling for computation of the flow and heat transfer, also, require knowledge of the flow as well as transport data to check the validity of models and their accuracy. GRA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A90-13784
ON A PITCH CONTROL LAW FOR A CONSTANT GLIDE SLOPE THROUGH WINDSHEARS
L. M. B. C. CAMPOS (Instituto Superior Tecnico, Lisbon, Portugal) Aeronautical Journal (ISSN 0001-9240), vol. 93, Oct. 1989, p. 290-300. Research supported by the Instituto Nacional de Investigacao Cientifica. refs
Copyright

The present equations of motion for an aircraft's constant glide-slope in the presence of arbitrary headwinds or tailwinds and upflows or downflows are integrated analytically. The case of an approach through downburst conditions leads to winds that can be simplified to the conditions of a one-period sinusoidal wind along the flight-path which changes from a headwind to a tailwind. Data sheets are presented for three combinations of the head-to-tailwind amplitude and downflow intensity; each sheet contains plots of the aircraft-incidence schedule that will exactly cancel the windshear effects, together with the ground-speed and air-speed profiles that will keep the aircraft flying along the original glide slope. O.C.

A90-14334
A LOW COST STALL/SPIN SIMULATOR
M. G. NAGATI (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 10 p.

(Contract DOT-FA03-86-R-60039)
(SAE PAPER 891022) Copyright

A method for simulating flight conditions into stall, poststall spin entry and steady state spin has been developed using a high performance graphics workstation. Its objective is to provide an easy and low-cost means of evaluating the high angular rate and high angle of attack handling qualities of preliminary general aviation configurations. Wing forces and moments are integrated over the span to provide real-time solutions of the full nonlinear equations of motion and provide visual simulation of aircraft motion from the pilot's viewpoint, or an outside view of the aircraft. The technique was found to be in good agreement with flight test data of a light aircraft, and offers a simple means of assessing the stall/spin characters of light aircraft configurations. Author

A90-14345* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INVESTIGATIONS OF MODIFICATIONS TO IMPROVE THE SPIN RESISTANCE OF A HIGH-WING, SINGLE-ENGINE, LIGHT AIRPLANE
G. S. MANUEL, D. J. DICARLO, H. P. STOUGH, III, P. W. BROWN, and R. A. STUEVER (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 9 p. refs
(SAE PAPER 891039) Copyright

A general aviation aircraft with drooped leading edge modifications for improvement of lateral stability at high angles of attack has been flight tested in combination with a ventral fin which improves directional stability. The two modifications were assessed in light of spin-resistance criteria proposed for incorporation into FAA certification regulations. The configuration combining outboard wing leading-edge droop and a ventral fin yielded a substantial increase in spin resistance, but fell short of all requirements encompassed by the proposed spin-resistance criteria. O.C.

A90-14355
REAL-TIME DECISION MAKING FOR AUTONOMOUS FLIGHT CONTROL
SULYUTH SWANGWANNA (Wichita State University, KS) and JAN M. ZYTKOW (George Mason University, Fairfax, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 9 p. Research supported by DARPA. refs
(Contract DAAL03-87-G-0003; N00014-87-K-0874)
(SAE PAPER 891053) Copyright

This paper describes a software system that makes real time decisions for an autonomous airplane in a simulated combat environment. It utilizes a network of plans and goals and selects them dynamically, according to the changing circumstances and to the mission goals. Architecture of the system allows for quick, hierarchical selection of plans and flexible execution by adjusting plan instantiation to the varying situation. The system monitors is own performance, checking for the safety, resources, and effectiveness of currently executed plans and dropping those that become dangerous or counterproductive. The architecture of the system allows for a prompt response to dangerous situations by suspending the currently executed plan and invoking an emergency plan. The system can follow commands from the formation leader or ground control. Commands may be very specific, but the system can also follow commands on higher levels of abstraction, deciding autonomously on necessary details. Author

A90-14728#
MINIMUM-TIME TURNS USING VECTORED THRUST
GARRET L. SCHNEIDER and GEORGE W. WATT (USAF, Institute of Technology, Wright-Patterson AFB, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 777-782. Previously cited in issue 21, p. 3492, Accession no. A88-50180. refs

A90-14729#
DESIGN OF ATTITUDE AND RATE COMMAND SYSTEMS FOR HELICOPTERS USING EIGENSTRUCTURE ASSIGNMENT
WILLIAM L. GARRARD, EICHER LOW, and SCOTT PROUTY (Minnesota, University, Minneapolis) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 783-791. Previously cited in issue 21, p. 3494, Accession no. A88-50238. refs
(Contract DAAL03-86-K-0056)
Copyright

A90-14730#
THEORY FOR AIRCRAFT HANDLING QUALITIES BASED UPON A STRUCTURAL PILOT MODEL
RONALD A. HESS (California, University, Davis) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 792-797. Previously cited in issue 22, p. 3543, Accession no. A87-50538. refs
Copyright

A90-14747*# Systems Technology, Inc., Hawthorne, CA.
LITERAL SINGULAR-VALUE-BASED FLIGHT CONTROL SYSTEM DESIGN TECHNIQUES
DUANE T. MCRUER, THOMAS T. MYERS, and PETER M. THOMPSON (Systems Technology, Inc., Hawthorne, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 913-919. Previously cited in issue 05, p. 599, Accession no. A87-17942. refs
(Contract NAS1-17987)
Copyright

A90-15423#
AN ANALYSIS OF THE POSSIBILITY OF USING DIRECT CONTROL OF THE LIFTING FORCE FOR MODIFYING THE FLYING QUALITIES OF AIRCRAFT [ANALIZA MOZLIWOSCI WYKORZYSTANIA BEZPOSREDNIEGO STEROWANIA SILA NOSNA DO MODYFIKACJI WLASNOSCI PILOTAZOWYCH SAMOLOTU]
STANISLAW BOCIEK and ANDRZEJ TOMCZYK (Rzeszow, Politechnika, Poland) Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 114-115, 1988, p. 22-39. In Polish. refs

The present paper contains a simplified analysis of the behavior of an aircraft with a control system in which the displacement of the elevator is accompanied by an appropriate displacement of the flaps. This is possible to achieve by direct lift control, the application of which modifies the flying qualities of the aircraft, some transient processes being changed as well as some aerodynamic characteristics. To enable an estimate of these phenomena, an efficacy index is introduced for direct lift control, and its influence on these characteristics is studied. A numerical example is given to show the usefulness of the index and to illustrate the results of an application of the aircraft control technique. Author

A90-15424#
EVALUATION OF THE DYNAMIC PROPERTIES OF THE AUTO-PILOT SERVO OF A SINGLE-ROTOR HELICOPTER THROUGH LABORATORY TESTING [OCENA WLASNOSCI DYNAMICZNYCH SERWOMECHANIZMU WYKONAWCZEGO AUTOPILOTA HELIKOPTERA JEDNOWIRNIKOWEGO DROGA BADAN LABORATORYJNYCH]
PIOTR TOMASZEWICZ (Instytut Lotnictwa, Warsaw, Poland) Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 114-115, 1988, p. 40-54. In Polish.

The subject matter of the present discussion are the results of tests of the dynamics of the control servo of a single-rotor helicopter. The structure of the servo, which is treated as a control system, is divided into a control part and a motor part. The results of the measurement of the time constant and the maximum velocity of the control part of the servo are presented as a function of the gain of the feedback loop. It is shown that the dynamic possibilities of the actuator motor part are not fully used by the control part in the course of operation of the device in the autopilot system. The cause of the unsatisfactory dynamic properties of the electrohydraulic control servo is shown to lie in the structure of the electronic part of the servo and consist in the narrow adjustment

margin of the gain of the feedback loop. The results of the analysis show the importance of making, at the stage of preliminary design, correct technical assumptions for each particular subassembly. Author

A90-16521* California Univ., Los Angeles.
A SIMPLE ACTIVE CONTROLLER TO SUPPRESS HELICOPTER AIR RESONANCE IN HOVER AND FORWARD FLIGHT
P. P. FRIEDMANN and M. D. TAKAHASHI (California, University, Los Angeles) IN: Dynamics of controlled mechanical systems; Proceedings of the IUTAM/IFAC Symposium, Zurich, Switzerland, May 30-June 3, 1988. Berlin and New York, Springer-Verlag, 1989, p. 163-180. refs
(Contract NAG2-209; NAG2-477)
Copyright

A coupled rotor/fuselage helicopter analysis with the important effects of blade torsional flexibility, unsteady aerodynamics, and forward flight is presented. This model is used to illustrate the effect of unsteady aerodynamics, forward flight, and torsional flexibility on air resonance. Next, a nominal configuration, which experiences air resonance in forward flight, is selected. A simple multivariable compensator using conventional swashplate inputs and a single body roll rate measurement is then designed. The controller design is based on a linear estimator in conjunction with optimal feedback gains, and the design is done in the frequency domain using the loop-transfer recovery method. The controller is shown to suppress the air resonance instability throughout wide range helicopter loading conditions and forward flight speeds. Author

N90-11751*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED WIND-TUNNEL STUDY OF REACTION CONTROL-JET EFFECTIVENESS FOR HOVER AND TRANSITION OF A STOVL FIGHTER CONCEPT
DONALD R. RILEY, GAUTAM H. SHAH, and RICHARD E. KUHN (Kuhn, Richard E., San Diego, CA) Washington Dec. 1989 39 p
(NASA-TM-4147; L-16616; NAS 1.15:4147) Avail: NTIS HC A03/MF A01 CSCL 01/3

A brief wind-tunnel study was conducted in the Langley 12-Foot Low-Speed Tunnel to determine reaction control-jet effectiveness and some associated aerodynamic characteristics of a 15 percent scale model of the General Dynamics E-7A STOVL fighter/attack aircraft concept applicable to hover and transition flight. Tests were made with the model at various attitude angles in the tunnel test section and at various tunnel airspeeds for a range of control-jet nozzle pressure ratios. Eight reaction control-jets were tested individually. Four jets were at the design baseline locations providing roll, pitch, and yaw control. Comparisons of measured data with values calculated using empirical methods were made where possible. Author

N90-11752*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATIONS OF FLIGHT CONTROL SYSTEM METHODS TO AN ADVANCED COMBAT ROTORCRAFT
MARK B. TISCHLER, JAY W. FLETCHER, PATRICK M. MORRIS (Army Aviation Research and Development Command, Moffett Field, CA.), and GEORGE T. TUCKER Jul. 1989 62 p Presented at the Royal Aeronautical Society International Conference on Helicopter Handling Qualities and Control, London, England, 15-17 Nov. 1988
(NASA-TM-101054; A-89006; USAAVSCOM-CP-89-A-002; NAS 1.15:101054; AD-A211906) Avail: NTIS HC A04/MF A01 CSCL 01/3

Advanced flight control system design, analysis, and testing methodologies developed at the Ames Research Center are applied in an analytical and flight test evaluation of the Advanced Digital Optical Control System (ADOCS) demonstrator. The primary objectives are to describe the knowledge gained about the implications of digital flight control system design for rotorcraft, and to illustrate the analysis of the resulting handling-qualities in the context of the proposed new handling-qualities specification for rotorcraft. Topics covered in-depth are digital flight control design and analysis methods, flight testing techniques, ADOCS handling-qualities evaluation results, and correlation of flight test results with analytical models and the proposed handling-qualities specification. The evaluation of the ADOCS demonstrator indicates desirable response characteristics based on equivalent damping and frequency, but undersirably large effective time-delays (exceeding 240 m sec in all axes). Piloted handling-qualities are found to be desirable or adequate for all low, medium, and high pilot gain tasks; but handling-qualities are inadequate for ultra-high gain tasks such as slope and running landings. Author

N90-11753*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A DESIGN PROCEDURE FOR THE HANDLING QUALITIES OPTIMIZATION OF THE X-29A AIRCRAFT
JOHN T. BOSWORTH and TIMOTHY H. COX Sep. 1989 21 p Presented at the Guidance, Navigation, and Control Conference, Boston, MA, 14-16 Aug. 1989 Previously announced in IAA as A89-52529
(NASA-TM-4142; H-1548; NAS 1.15:4142; AIAA-89-3428) Avail: NTIS HC A03/MF A01 CSCL 01/3

A design technique for handling qualities improvement was developed for the X-29A aircraft. As with any new aircraft, the X-29A control law designers were presented with a relatively high degree of uncertainty in their mathematical models. The presence of uncertainties, and the high level of static instability of the X-29A caused the control law designers to stress stability and robustness over handling qualities. During flight test, the mathematical models of the vehicle were validated or corrected to match the vehicle dynamic behavior. The updated models were then used to fine tune the control system to provide fighter-like handling characteristics. A design methodology was developed which works within the existing control system architecture to provide improved handling qualities and acceptable stability with a minimum of cost in both implementation as well as software verification and validation. IAA

N90-11754# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
STABILITY AND CONTROL DERIVATIVES OF THE DE HAVILLAND DHC-2 BEAVER AIRCRAFT
R. T. H. TJEE and J. A. MULDER Aug. 1988 151 p
(PB89-217525; LR-556) Avail: NTIS HC A08/MF A01 CSCL 01/3

The report presents a database of stability derivatives of the De Havilland DHC-2 BEAVER experimental aircraft of the Delft University of Technology at various stationary nominal flight conditions. To compute these stability derivatives a nonlinear aerodynamic model is used. The flight test data of this model is based on data derived from the DHC-2 BEAVER test flights of the 1977 and 1978 period. The stability derivatives are presented at several nominal flight conditions throughout the normally used flight envelope of the aircraft. GRA

N90-11756# Techno-Sciences, Inc., Greenbelt, MD.
ROBUST CONTROL DESIGN FOR FLIGHT CONTROL Final Report, Jul. 1988 - Mar. 1989
WILLIAM H. BENNETT, HAROLD G. KWATNY, and KEITH GLOVER Jul. 1989 92 p
(Contract F33615-88-C-3606)
(AD-A211957; TSI-89-04-06-WB; WRDC-TR-89-3063) Avail: NTIS HC A05/MF A01 CSCL 01/4

The application of new and advanced methods of control law synthesis for robust stabilization were studied with respect to a combination of both unstructured model uncertainty (arising from neglected parasitic dynamics) and structured model uncertainty (arising from parametric variations which occur as flight conditions change). Efforts focused on the characterization of a class of nonlinear models for longitudinal dynamics of aircraft in level flight subject to changes in static stability. Such relaxed stability aircraft

configurations are currently at issue in a wide variety of advanced designs including commercial transport and high performance aircraft. The control design approach employs H-infinity synthesis methods for optimal robust stabilization for the unstructured model uncertainty, and the requirement of worst case (i.e., robust) design for parametric uncertainty is included using a minimax optimization criteria. A class of flight control models with physically based parametric uncertainty were examined. For these models, the solution of the minimax or worst case design is achieved by a straightforward procedure which can be readily combined with the requirements for robustness to parasitic dynamics using the closed form solution of the optical robust stabilization method. GRA

N90-11757*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF FLYING QUALITIES DERIVED FROM IN-FLIGHT AND GROUND-BASED SIMULATORS FOR A JET-TRANSPORT AIRPLANE FOR THE APPROACH AND LANDING PILOT TASKS
WILLIAM D. GRANTHAM Washington Dec. 1989 32 p
(NASA-TP-2962; L-16609; NAS 1.60:2962) Avail: NTIS HC A03/MF A01 CSCL 01/3

The primary objective was to provide information to the flight controls/flying qualities engineer that will assist him in determining the incremental flying qualities and/or pilot-performance differences that may be expected between results obtained via ground-based simulation (and, in particular, the six-degree-of-freedom Langley Visual/Motion Simulator (VMS)) and flight tests. Pilot opinion and performance parameters derived from a ground-based simulator and an in-flight simulator are compared for a jet-transport airplane having 32 different longitudinal dynamic response characteristics. The primary pilot tasks were the approach and landing tasks with emphasis on the landing-flare task. The results indicate that, in general, flying qualities results obtained from the ground-based simulator may be considered conservative-especially when the pilot task requires tight pilot control as during the landing flare. The one exception to this, according to the present study, was that the pilots were more tolerant of large time delays in the airplane response on the ground-based simulator. The results also indicated that the ground-based simulator (particularly the Langley VMS) is not adequate for assessing pilot/vehicle performance capabilities (i.e., the sink rate performance for the landing-flare task when the pilot has little depth/height perception from the outside scene presentation). Author

N90-11758# Dynetics, Inc., Huntsville, AL.
ADAPTIVE CONTROL LAW DESIGN FOR MODEL UNCERTAINTY COMPENSATION Final Report, Aug. 1988 - Jan. 1989
J. E. SORRELLS 14 Jun. 1989 96 p
(Contract F33615-88-C-3609; AF PROJ. 3005)
(AD-A211712; TR-89-WPAFB-3609-033; WRDC-TR-89-3061)
Avail: NTIS HC A05/MF A01 CSCL 01/4

Disturbance Accommodating Control (DAC) principles were applied to the design of a baseline aerospace flight control system. The resulting DAC controller designs were evaluated in terms of their ability to maintain an ideal model response when the closed loop system was subjected to significant uncertainties. These uncertainties included parameter perturbations, external disturbances, and unmodelled dynamics. The DAC designs were compared to other adaptive techniques, including Self-Tuning Regulator (STR) and Model Reference Adaptive Control (MRAC) concepts. These designs were also compared to a classical Proportional-Integral-Derivative (PID) controller. All of the adaptive controller designs were judged relative to each other and relative to the PID design, in terms of performance, design, complexity, and confidence of operation (reliability). In every case the controllers designed using Dynetics innovative approach were able to equal or surpass the STR and MRAC controllers in terms of performance robustness while preserving a linear time-invariant implementation structure. GRA

N90-11759# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli da Combattimento.
EVOLUTION OF FLIGHT COMMANDS IN AERITALIA DESIGN [EVOLUZIONE DEI COMANDI DI VOLO NELLA PROGETTAZIONE AERITALIA]
GIAN MARIO AVAGNINA and PIER LUIGI FERRARIS 1989 13 p In ITALIAN; ENGLISH summary
(ETN-89-95211) Avail: NTIS HC A03/MF A01

An overview of the aircrafts designed either independently or in collaboration is made with reference to handling qualities and flight control system design problems. The analysis shows that the technological evolution transformed both the aerodynamic configuration and the basic design of the control system. ESA

N90-11760# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (Germany, F.R.). Abteilung Regelung.
CONTROLLER DESIGN FOR ACTIVE VIBRATION SUPPRESSION OF A HELICOPTER
NORBERT GAUS and REINHOLD STEINHAUSER Jan. 1989 141 p In GERMAN; ENGLISH summary
(DFVLR-FB-89-20; ISSN-0171-1342; ETN-89-95315) Avail: NTIS HC A07/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Federal Republic of Germany, 49.50 deutsche marks

A controller is designed to suppress vibrations, which are transmitted from the helicopter rotor to its fuselage. To solve the corresponding regulator problem by output-feedback, notch-filters are introduced in the controller structure. A comprehensive linear system analysis, where invariant system zeros give major hints, leads to a suitable extension of the controller structure and an initial controller design. The final controller coefficients are determined by optimizing a vector performance index. The result is compared to linear quadratic optimal controllers and then checked for robustness taking both model extensions and sensor or actuator failing into consideration. ESA

N90-12621# European Space Agency, Paris (France).
A ROBUST DIGITAL MODEL FOLLOWING CONTROLLER FOR HELICOPTERS
GERHARD BOUWER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) Apr. 1989 159 p Transl. into ENGLISH of Ein Robuster Digitaler Modellfolgeregler fuer Hubschrauber (Brunswick, Fed. Republic of Germany, DFVLR), Jan. 1988 157 p Original language document was announced as N88-27203
(ESA-TT-1041; DFVLR-FB-88-07; ETN-89-95389) Avail: NTIS HC A08/MF A01; original German version available from DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 40.50 Deutsche marks

The development, design and testing of a model following control system for helicopters is reported. In order to comply with the operating limits, a special actuator simulation system is developed. The investigations are based on a model with simple dynamics and a model for flight simulation. Numerical simulation is applied to investigate the effectiveness of the closed loop control system both in model following control and in disturbance rejection. The limits of model following control are illustrated by variation in model parameters. The possibilities of inflight simulation are demonstrated. ESA

N90-12622# Systemes et Audio Frequences, Paris (France).
INTEGRATION OF A CENTRALIZED MULTIPLEXED CONTROL UNIT INTO THE COCKPIT OF AN AIRCRAFT Final Report [INTEGRATION DANS UN POSTE DE PILOTAGE D'AERONEF D'UN ORGANE DE COMMANDE CENTRALISEE MULTIPLEXEE]
16 Feb. 1989 113 p In FRENCH
(Contract DRET-84-34-481-00-470-75-01)
(F6150-DT410-1-88329; ETN-89-95276) Avail: NTIS HC A06/MF A01

A centralized multiplexed command unit developed for the cockpit of an aircraft is described. The unit includes a screen

which displays information usually available on a wide variety of dashboard instruments. An optimization of the man/machine interface is achieved by minimizing the number of hand movements, body movements and eye movements necessary for operation of the aircraft. The unit has a keyboard of twenty multifunctional keys and eleven unifunctional keys. Details of the operation of such a command unit are given. ESA

N90-12624# Dynamic Controls, Inc., Dayton, OH.
ADVANCED ACTUATION SYSTEMS DEVELOPMENT, VOLUME 1 Final Report, May 1983 - Jan. 1987
GAVIN D. JENNEY, HARRY W. SCHREADLEY, JOHN A. ANDERSON, WILLIAM G. TALLEY, and CARL A. ALLBRIGHT Aug. 1989 233 p
(Contract F33615-83-C-3600)
(AD-A213334; WRDC-TR-89-3076-VOL-1) Avail: NTIS HC A11/MF A02 CSCL 01/4

Six different research and development activities in flight control actuation are described. The activities are: (1) the development and test of a unique linear actuator sealing system for high-pressure systems, (2) the development and test of a digital servovalve using piezo-controlled high-speed solenoid valves, (3) the performance evaluation of an F-15 rudder actuator under applied loads, (4) the performance evaluation of a Mission Adaptive Wing section under different load conditions, (5) the evaluation of output impedance modification of an electrohydraulic actuator for flutter suppression, and (6) the development and test of a direct drive valve and electronics (analog and digital) for an F-16 Horizontal Tail/FlapeRon actuator. This volume presents activities 1, 2, and 3. Volume 2 presents activities 4, 5, and 6. GRA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A90-15422#
CRITERIA FOR EVALUATING THE FLIGHT DYNAMICS MODEL OF FLIGHT SIMULATORS [KRYTERIA OCENY MODELU DYNAMIKI LOTU W TRENINGOWYCH SYMULATORACH LOTU]
JANUSZ M. MORAWSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 114-115, 1988, p. 3-21. In Polish. refs

The principal aspects of developing a flight dynamics model for a flight simulator are discussed. Some methods for reducing the initial model, both classical and based on a pragmatic simulation, are considered. The latter concept adopts as a criterion of similarity between the simulation model and the real flight, the identity of the perceptions of the simulator used and the real pilot. Some objective and subjective criteria for evaluating a model are formulated according to the principles of pragmatic approach. The aim of these procedures is, in general, to make a subjective evaluation as reliable as the measurement results. Author

A90-15743#
WIND TUNNEL TESTING OF HIGH BLOCKAGE MODELS
M. SHIVAKUMARA SWAMY (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 40, May 1988, p. 119-130.

Sophisticated methods have become available for computing wind tunnel boundary corrections; this has facilitated the use of smaller wind tunnel facilities with relatively large models, involving higher blockage ratios than previously used. This paper describes an effort to verify this concept by correlating test results on a wing-body model obtained from a smaller tunnel with those from a larger tunnel after applying appropriate corrections. It is verified that even smaller facilities can be used to test reasonably higher blockage models when sophisticated methods are available for the computation of the wall boundary corrections. B.J.

A90-15873
SMOOTHING THE WAY TO FUTURE DESIGNS - A NEW TECHNIQUE FOR WIND-TUNNEL MEASUREMENTS
New-Tech News (ISSN 0935-2694), no. 3, 1989, p. 24, 25.
Copyright

This paper describes experiments performed in the ONERA high-speed wind tunnel with a large-scale (5-m 4.5-ton) wing model fitted with various control elements for varying the experimental setup and with numerous sensors and transmitters for taking measurements. Among the test parameters that were varied in these experiments were the Mach number, the angle of attack, the sweepback angle, and the combination of wing flaps and rigid wing sections. Results obtained when the half-scale wing 'flew' at a speed of about 900 km/hr demonstrated that a correlation exists between laminar flow across the wing in free flight and laminar flow in the wind tunnel under similar conditions. I.S.

N90-11761 Federal Aviation Administration, Atlantic City, NJ.
ANALYSIS OF HELIPORT ENVIRONMENTAL DATA: INDIANAPOLIS DOWNTOWN HELIPORT, WALL STREET HELIPORT. VOLUME 2: WALL STREET HELIPORT DATA PLOTS
ROSANNE M. WEISS, JOHN G. MORROW, DONALD GALLAGHER, MARK DIMEO, and SCOTT ERLICHMAN May 1989 1128 p
(DOT/FAA/CT-TN87/54-VOL-2) Avail: Issuing Activity

During the summer of 1987 heliport environmental data were collected at Indianapolis Downtown Heliport and at New York's Wall Street Heliport. The purpose of this data collection activity was to obtain measures of rotorwash in the heliport environment due to maneuvering helicopters, and to obtain pilot perceptions and observations concerning maneuvering and parking separation criteria. Ten wind vector transmitters were situated at various locations around the heliport in order to gather information to describe the rotorwash induced wind speed and direction changes. Pilot interviews were also conducted at these heliports. Volume 1 of this report provides a summary of the results of this activity. Volume 3 provides the plots generated from the wind sensor data collected at the Indianapolis Downtown Heliport. This volume (Volume 2) provides the plots generated from the wind sensor data collected at New York's Wall Street Heliport. The results of this study will be considered in future modifications of the Federal Aviation Administration (FAA) Heliport Design Advisory Circular, AC 150/5390-2. Author

N90-11762# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
ILS MATHEMATICAL MODELING STUDY OF THE EFFECTS OF PROPOSED HANGAR CONSTRUCTION AT THE ORLANDO INTERNATIONAL AIRPORT, RUNWAY 17R, ORLANDO, FLORIDA Technical Report, Aug. 1989
JAMES D. RAMBONE and JOHN E. WALLS Sep. 1989 21 p
(DOT/FAA/CT-TN89/52) Avail: NTIS HC A03/MF A01

Described here is the instrument landing system (ILS) math modeling performed by the Federal Aviation Administration (FAA) Technical Center at the request of the Southern Region. Computed localizer data are presented showing the effects of two hangar buildings (Braniff and Comair) on the performance of an ILS localizer proposed for runway 17R at the Orlando International Airport. The Southern Region is concerned that radio frequency (RF) signal reflections from the two hangars may degrade the localizer course beyond Category II/III tolerances. Modeled course structure results indicate that Category II/III localizer performance should be obtained with the Wilcox Mark II, 14-element, dual-frequency log periodic antenna with both hangar buildings constructed at the currently proposed locations. Computed clearance orbit results indicate satisfactory linearity, course crossover, and signal clearance levels. Data are also presented showing the computed performance for a glide slope proposed

for runway 17R at the Orlando International Airport. The null reference glide slope will be located 1050 feet back from runway threshold and 400 feet left offset of centerline. Glide slope modeling computed only the effect of terrain in front of the antenna system and was conducted with the GTD-2D model because of limited terrain data availability. Modeled path structure and level run plots are provided for the proposed null reference system. Author

N90-11765# Wichita State Univ., KS. Inst. for Aviation Research.
STALL/SPIN/FLIGHT SIMULATION Final Report
M. G. NAGATI Sep. 1989 68 p
(Contract DTFA03-86-C-00041)
(DOT/FAA/CT-88/28) Avail: NTIS HC A04/MF A01

The work performed for stall-spin resistant design aids for aircraft is summarized. Two major areas were investigated. First, the solution of the non-linear equations of motion with on-line computation of the aerodynamic moments and visual display of the pilot's view and views of the aircraft. This enables evaluation of the simulator and the quality of the solution by pilots and engineers. Second, a method for predicting the aerodynamics of wings near and beyond stall was developed. It serves the purpose of selecting planforms for spin resistant aircraft. This work demonstrates the viability and promise of these approaches against spin. Author

N90-11766# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli da Combattimento.
THE AERODYNAMIC EXPERIMENTAL CENTER OF AERITALIA: COMBAT AIRCRAFT GROUP [IL CENTRO DI SPERIMENTAZIONE AERODINAMICA DELL'AERITALIA - GRUPPO VELIVOLI DA COMBATTIMENTO]
E. BARBANTINI and G. BUCCIANTINI 1989 19 p In ITALIAN
(ETN-89-95213) Avail: NTIS HC A03/MF A01

The two subsonic wind tunnels developed to test transport (G222) and combat (G91y, tornado, AMX) aircraft design are described. The design principles and the integration of experimental tests with theoretical aerodynamics mathematical models are discussed. The second wind tunnel is smaller and adapted to flow visualization and preliminary test studies. ESA

N90-11768# Royal Aerospace Establishment, Farnborough (England).
COMPARISON OF THE RESULTS OF TESTS ON A300 AIRCRAFT IN THE RAE 5 METRE AND ONERA F1 WIND TUNNELS
C. QUEMARD and P. B. EARNSHAW 26 May 1988 28 p Previously announced as N89-16849
(RAE-TM-AERO-2130; BR108113; ETN-89-94334) Copyright Avail: Defence Research Information Centre, Kentigem House, 65 Brown Street, Glasgow, G2 8EX, Scotland

Studies of the A300 Airbus aircraft were carried out in two pressurized low speed wind tunnels. Initially comparison of the results obtained in the two facilities, with the same model mounted on an identical three strut support, showed discrepancies which in the case of lift coefficient amounted to 2.5 percent. Comparison of all of the procedures used in processing the measurements led to a series of modifications in data reduction techniques in the two facilities. When these modifications are all taken into account, the results on lift and drag on the A300 provided by the two tunnels show good agreement, confirming the accuracy of the measurement techniques and the broad framework of the corrections. ESA

N90-12522*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HOT-FILM SYSTEM FOR TRANSITION DETECTION IN CRYOGENIC WIND TUNNELS
CHARLES B. JOHNSON, DEBRA L. CARRAWAY, P. CALVIN STAINBACK, and M. F. FANCHER (Douglas Aircraft Co., Inc., Long Beach, CA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 358-376 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 14/2

It is well known that the determination of the location of boundary-layer transition is necessary for the correct interpretation of aerodynamic data in transonic wind tunnels. In the late 1970s the Douglas Aircraft Company developed a vapor deposition hot-film system for transition detection in cryogenic wind tunnels. Tests of the hot-films in a low-speed tunnel demonstrated the ability to obtain on-line transition data with an enhanced simultaneous hot-film data acquisition system. The equipment design and specifications are described. B.G.

N90-12526*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BASIC AERODYNAMIC RESEARCH FACILITY FOR COMPARATIVE STUDIES OF FLOW DIAGNOSTIC TECHNIQUES
GREGORY S. JONES, LUTHER R. GARTRELL, and P. CALVIN STAINBACK *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 401-406 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 14/2

Current flow diagnostic research efforts are focusing on higher order flow field data bases, such as those generated by laser velocimetry (LV), hot-wire anemometry, and multi-hole pressure probes. Recent low-speed comparisons of results obtained with LV and hot wires have revealed strengths and weaknesses of each instrument. A seeding study will be initiated to determine particulate tracking ability. B.G.

N90-12528*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT FLOW VISUALIZATION STUDIES IN THE 0.3-M TCT
WALTER L. SNOW, ALPHEUS W. BURNER, and WILLIAM K. GOAD *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 412-419 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 14/2

Light beams are altered by refractive index changes; flow induced refractive index changes provide the impetus for conventional visualization techniques such as schlieren and shadowgraph. Unfortunately effects related to the flow can be masked by refractive index inhomogeneities external to the test section. A simple shadowgraph scheme was used to assess the flow quality of the Langley 0.3 meter Transonic Cryogenic Tunnel. When the penetration tubes were evacuated the quality of the shadowgraph improved dramatically. B.G.

N90-12555*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND FABRICATION REQUIREMENTS FOR LOW NOISE SUPERSONIC/HYPERSONIC WIND TUNNELS
IVAN E. BECKWITH, FANG-JENG CHEN, and MUJEEB R. MALIK (High Technology Corp., Hampton, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 947-964 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 14/2

A schematic diagram of the new proposed Supersonic Low Disturbance Tunnel (SLDT) is shown. Large width two dimensional rapid expansion nozzles guarantee wide quiet test cores that are well suited for testing models at large angle of attack and for swept wings. Hence, this type of nozzle will be operated first in the new proposed large scale SLDT. Test results indicate that the surface finish of pilot nozzles is critical. The local roughness Reynolds number criteria R sub k is approx. = 10 will be used to specify allowable roughness on new pilot nozzles and the new proposed tunnel. Experimental data and calculations for M = 3.0, 3.5, and 5.0 nozzles give N-factors from 6 to 10 for transition caused by Goertler vortices. The use of N is approx. = 9.0 for the Goertler instability predicts quiet test cores in the new M = 3.5 and M = 6.0 axisymmetric long pilot nozzles that are 3 to 4 times longer than observed in the test nozzles to date. The new nozzles utilize a region of radial flow which moves the inflection point far downstream and delays the onset and amplification of the Goertler vortices. Author

N90-12625*# Vigyan Research Associates, Inc., Hampton, VA.
RESIDUAL INTERFERENCE ASSESSMENT IN ADAPTIVE WALL WIND TUNNELS
A. V. MURTHY Sep. 1989 32 p
(Contract NAS1-18585)
(NASA-CR-181896; NAS 1.26:181896) Avail: NTIS HC A03/MF A01 CSCL 14/2

A two-variable method is presented which is suitable for on-line calculation of residual interference in airfoil testing in the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-M TCT). The method applies the Cauchy's integral formula to the closed contour formed by the contoured top and bottom walls, and the upstream and downstream ends. The measured top and bottom wall pressures and position are used to calculate the correction to the test Mach number and the airfoil angle of attack. Application to specific data obtained in the 0.3-M TCT adaptive wall test section demonstrates the need to assess residual interference to ensure that the desired level of wall streamlining is achieved. A FORTRAN computer program was developed for on-line calculation of the residual corrections during airfoil tests in the 0.3-M TCT. Author

N90-12627# Pennsylvania Transportation Inst., University Park.
ANALYTICAL AND EXPERIMENTAL STUDY OF RUNWAY RUNOFF WITH WIND EFFECTS Final Report, Feb. 1986 - Jun. 1989
J. R. REED, D. F. KIBLER, and G. A. KRALLIS Oct. 1989 65 p Prepared for Naval Air Engineering Center, Lakehurst, NJ
(Contract DOT-FA74WAI-432)
(PTI-8948; DOT/FAA/CT-TN89/59) Avail: NTIS HC A04/MF A01

This study is an extension of an earlier study that investigated the drainage efficiency of rectangular runway grooves in reducing runoff depths and the potential for hydroplaning. A mathematical model based on kinematic wave theory was developed and compared to the results of experiments conducted on a concrete slab subject to artificially produced rainfall. Parallel grooves were cut in the slab along its 30-ft length, which sloped at a typical 1.5 percent normal to the flight path. The 30-ft dimension models only the central portion of a single runway lane perhaps 100 ft wide. It was concluded that the grooves decreased runoff depths appreciably, more so as the spacing between grooves decreased. The current investigation adds wind velocity (15 mph) and direction to the variables considered in the previous study, with all other conditions essentially the same. This final report describes: (1) a kinematic wave model with wind superimposed (Phase 1); and (2) experiments conducted to calibrate the model (Phase 2). The hydraulic resistance of the slab and the calibration constants of the models were determined from the experiment. Curves of water depths versus position on a runway were predicted from the model and plotted out to 100 ft. Data points in the first 26 ft were plotted on the same graphs as a comparison. A conservative estimate of the runoff depth increase due to a direct cross wind to the runway is 0.04 inch for all conditions. Increases that are somewhat larger are restricted to smaller runoff depths. The breakout point for runoff in grooves appears to shift upstream about 25 percent of the breakout distance without wind. Author

N90-12628# National Aerospace Lab., Amsterdam (Netherlands).
DEVELOPMENT OF A MULTI-COMPONENT INTERNAL STRAIN-GAUGE BALANCE FOR MODEL TESTS IN A CRYOGENIC WIND TUNNEL
J. F. BALJEU 1988 99 p
(NLR-TR-88157-U) Avail: NTIS HC A05/MF A01

A three-component internal strain-gauge balance for use in a cryogenic wind tunnel has been developed by National Aerospace Laboratory NLR. With this balance model tests were performed in the NASA Langley 0.3-m Transonic Cryogenic Tunnel. The results are discussed with a view to the development of strain-gauge balances for the European Transonic Wind Tunnel (ETW). Author

N90-12629 Physics and Electronics Lab. TNO, The Hague (Netherlands).
THE COMPARISON OF THE AIRBASE SIMULATION MODELS AIRBASE AND SUSTAINED
P. SCHULEIN and E. A. M. THEUNISSEN Sep. 1988 41 p In DUTCH; ENGLISH summary
(Contract A84/KLU/046)
(FEL-1988-66; TD88-1107; ETN-89-94470) Copyright Avail: TNO Physics and Electronics Lab., P.O. Box 96864, 2509 JG The Hague, Netherlands

The results of the comparison between two airbase simulation models are reported. A successor of the airbase model, named sustained, is constructed. Based on this comparison the sustained model is considered to be a useful tool and is designed to replace airbase. ESA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A90-13442#
PRELIMINARY ANALYSIS OF METHODOLOGY FOR ASSESSMENT OF PROPULSION SYSTEM FOR AEROSPACE PLANE
ZHONG-YUAN YE (Ministry of Aerospace Industry, Beijing, People's Republic of China) IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 6 p. refs
(IAF PAPER 89-307) Copyright

The conclusions on the assessments of a propulsion system for an aerospacecraft are known to be sometimes quite discrepant or even contrary to each other. This paper analyzes the cause of such discrepancies, examining the impact of the assessment methodology on the conclusion. It is shown that the impact of some fixed-variables data on conclusion must be considered. An improvement in assessment can be made by both a further step-by-step suboptimization analysis and by taking into account the airframe/propulsion integration effect. The payload mass is not always sensitive to all variables within the whole range, and an uncertainty of some variables cannot be avoided. It is concluded that a sensitivity analysis is necessary to estimate the impact of some variables on conclusion; the variables that are sensitive within certain range should be considered as critical ones to be studied, while the insensitive variables can be neglected. I.S.

A90-13976
ION, SATELLITE DIVISION'S INTERNATIONAL TECHNICAL MEETING, COLORADO SPRINGS, CO, SEPT. 19-23, 1988, PROCEEDINGS
Washington, DC, Institute of Navigation, 1989, 500 p. For individual items see A90-13977 to A90-14016.

Topics in satellite navigation technology are examined in reviews and reports. Sections are devoted to the current status of Navstar GPS, international developments and applications, GPS kinematic surveying, aerospace applications of GPS, integration of GPS, differential GPS, GPS receiver technology and systems, GPS integrity monitoring, and civil time-transfer and surface applications of GPS. Diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A90-13993#
INFLUENCE OF SATELLITE GEOMETRY, RANGE, CLOCK, AND ALTIMETER ERRORS ON TWO-SATELLITE GPS NAVIGATION
PHILIP D. BRIDGES (Nichols Research Corp., Huntsville, AL) IN:

ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 253-257.
(Contract DASG60-85-C-0053)

Flight tests were conducted at Yuma Proving Grounds, Yuma, AZ, to determine the performance of a navigation system capable of using only two GPS satellites. The effect of satellite geometry, range error, and altimeter error on the horizontal position solution were analyzed for time and altitude aided GPS navigation (two satellites + altimeter + clock). The east and north position errors were expressed as a function of satellite range error, altimeter error, and east and north Dilution of Precision. The equations for the Dilution of Precision were derived as a function of satellite azimuth and elevation angles for the two satellite case. The expressions for the position error were then used to analyze the flight test data. The results showed the correlation between satellite geometry and position error, the increase in range error due to clock drift, and the impact of range and altimeter error on the east and north position error. Author

A90-13996#
DYNAMIC INTERACTION OF SEPARATE INS/GPS KALMAN FILTERS (FILTER-DRIVING - FILTER DYNAMICS)
JOSEPH R. CUNNINGHAM and ZDZISLAW H. LEWANTOWICZ (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 273-281. refs

This paper examines the basic behavior of the inertial navigation system (INS) errors under high-dynamic conditions, such as combat maneuvering of a fighter aircraft. Examination of the INS linearized error dynamics eigenvalue migrations during various dynamic maneuvers reveals significantly stronger instability than the classical vertical channel instability. The Global Positioning System (GPS) offers high accuracy navigation performance benefits with global coverage, but is has limitations during the dynamic maneuvering of fighter aircraft. The optimal integration of the GPS with an INS promises synergistic system performance benefits not realizable with either system individually. A candidate maneuver is selected for which a covariance analysis is performed to demonstrate the performance characteristics of an optimally integrated INS/GPS system. Significant insight into the potential instability of a particular INS/GPS integration scheme is presented. The characteristic and unstable behavior of the INS error dynamics eigenfunctions provides the basis for the 'filter-driving-filter' performance analysis. Several phenomena were observed which should aid future efforts attempting to characterize the performance of various INS/GPS integration methods. Author

N90-11774*# McDonnell-Douglas Astronautics Co., Houston, TX.
INDEPENDENT ORBITER ASSESSMENT (IOA): ANALYSIS OF THE DISPLAYS AND CONTROLS SUBSYSTEM
W. H. TRAHAN and E. E. PRUST 1 Dec. 1987 182 p
(Contract NAS9-17650)
(NASA-CR-185563; NAS 1.26:185563; REPT-1.0-WP-VA87001-06)
Avail: NTIS HC A09/MF A01 CSCL 22/2

The results of the Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) are presented. The IOA approach features a top-down analysis of the hardware to determine failure modes, criticality, and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. This report documents the independent analysis results corresponding to the Orbiter Displays and Controls (D and C) subsystem hardware. The function of the D and C hardware is to provide the crew with the monitor, command, and control capabilities required for management of all normal and contingency mission and flight operations. The D and C hardware for which failure modes analysis was performed consists of the following: Acceleration Indicator (G-METER); Head Up Display (HUD); Display Driver Unit (DDU); Alpha/Mach Indicator (AMI); Horizontal Situation Indicator (HSI); Attitude Director Indicator (ADI); Propellant Quantity Indicator (PQI); Surface Position Indicator (SPI); Altitude/Vertical Velocity Indicator (AVVI); Caution and Warning Assembly (CWA); Annunciator Control Assembly (ACA); Event Timer (ET); Mission Timer (MT); Interior Lighting; and Exterior Lighting. Each hardware item was evaluated and analyzed for possible failure modes and effects. Criticality was assigned based upon the severity of the effect for each failure mode. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A90-14343
HISTORY OF AIRCRAFT PISTON ENGINE OILS - THE LAST FORTY YEARS
HERB A. POITZ and WELDON E. GARRELTS (Illinois, University, Savoy) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 12 p. refs
(SAE PAPER 891037) Copyright

An account is given of the development history of piston-engine aviation oils over the last 40 years, which witnessed the transition from straight mineral lubricants to ashless dispersant oils, and then to multiviscosity oils of various compounds (including synthetic-base stocks). The light aircraft industry now has a choice of many excellent oils to choose from. Attention is given to the consequence of the shift in oil container practices, which switched in the mid-1960s from metal quart cans to cardboard-composite cylindrical-wall cans with metal end-caps. All-plastic quart bottles are now widely used. O.C.

A90-14344
STRAIGHT ALCOHOL FUELS FOR GENERAL AVIATION AIRCRAFT
AUGUSTO M. FERRARA (FAA, Technical Center, Atlantic City, NJ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 11 p.
(SAE PAPER 891038) Copyright

The FAA Technical Center has evaluated straight methanol and ethanol fuels using an aircraft fuel system and engine which were installed on a dynamometer. The results of this program identified the conditions which should be used for hot fuel certification. Stoichiometric air-to-fuel ratios were identified as the most likely to result in either detonation or pre-ignition, and some material compatibility and operational problems were noted. The addition of small amounts of denaturing agents did not adversely affect the vapor lock behavior of the fuels. Straight methyl-tertiary-butyl ether was also evaluated. This material's high octane rating, moderate volatility, and relatively high energy density make it an attractive candidate when compared against either ethanol or methanol. Author

A90-14582
NUMERICAL MODELING OF THE COMBUSTION KINETICS OF HYDROCARBON FUELS IN AN ANNULAR COMBUSTION CHAMBER WITH ALLOWANCE FOR THE FORMATION OF HARMFUL IMPURITIES [O CHISLENNOM MODELIROVANII KINETIKI GORENIIA UGLEVODORODNYKH TOPLIV V KOL'TSEVOI KAMERE SGORANIIA S UCHETOM OBRAZOVANIIA VREDNYKH PRIMESEI]
T. IA. ALEKSEEVA, V. N. IGNAT'EV, and M. KH. MUKHAMETOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 88-90. In Russian. refs
Copyright

An approach to the numerical modeling of physicochemical processes in combustion chambers is proposed whereby all the process parameters are first calculated hydraulically, and the results

obtained (including temperature, velocity, and density data) are then used in a detailed analysis of the combustion of hydrocarbon fuels with allowance for the formation of harmful impurities, such as CO(x) and NO(x), and other compounds. Such an approach makes it possible to conduct all the calculations on a medium-capacity computer. A model annular combustion chamber with secondary air countercurrent in the internal annular duct is examined as an example. V.L.

A90-14588
CALCULATION OF VIBRATIONAL COMBUSTION LIMITS IN HELMHOLTZ RESONATOR-TYPE CHAMBERS [RASCHET GRANITS VIBRATSIONNOGO GORENIIA V KAMERAKH TIPA REZONATORA GEL'MGOL'TSA]
V. M. LARIONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 101, 102. In Russian.
Copyright

Reference is made to a previous study (Larionov and Nazarenko, 1988) in which vibrational combustion in a Helmholtz resonator-type chamber with a multichannel gas burner has been investigated experimentally. It has been shown that the self-excitation of vibrations is due to a feedback flow rate mechanism. Here, the limits of vibrational combustion are examined analytically, and the results obtained are found to be in good agreement with the experimental data. V.L.

A90-14652#
BALANCE MODEL OF THE PERFECTLY STIRRED REACTOR WITH THE DISCONTINUITY SURFACE
S. ZURKOWSKI (Instytut Lotnictwa, Warsaw, Poland) Archivum Combustionis (ISSN 0208-4198), vol. 8, no. 3-4, 1988, p. 331-349. refs

In this paper the system of assumptions to the model of the Perfectly Stirred Reactor (PSR) has been presented. From these assumptions, two models of the PSR arise: the model with a discontinuity surface and the voluminal model. The equivalence of these two models has been demonstrated. The voluminal balances of the total mass of mixture, the mass of reacting component, the kinetic energy, the thermal energy, the overall energy of motion, the internal energy and the total energy for the immobile reactor have been calculated. On the basis of obtained equations some general conclusions concerning the combustion chamber of a jet engine have been reached. It has also been shown how to get the main equations in the Vulis theory of reactors by applying the balances mentioned above. Autho

A90-14660
HIGHLY DAMAGE TOLERANT CARBON FIBER EPOXY COMPOSITES FOR PRIMARY AIRCRAFT STRUCTURAL APPLICATIONS
H. G. RECKER (BASF Structural Materials, Inc., Anaheim, CA), T. ALLSPACH, V. ALTSTADT, T. FOLDA, W. HECKMANN (BASF AG, Ludwigshafen, Federal Republic of Germany) et al. SAMPE Quarterly (ISSN 0036-0821), vol. 21, Oct. 1989, p. 46-51. refs
Copyright

Investigations of thermoplastic-modified epoxy neat resins for application in composite prepreg systems exhibiting a significant improvement in fracture toughness and damage tolerance have focused on a deeper understanding, and therefore superior control of morphology within phase-separated systems. A specific morphology has been observed which correlates with a distinct maximum in neat-resin fracture toughness; further understanding of structure-property relationships within laminates has also been used to optimize composite mechanical properties. Highly damage-tolerant systems possessing excellent hot/wet properties and solvent resistance have been thus obtained. O.C.

A90-15022
INTERMETALLIC COMPOUNDS FOR STRONG HIGH-TEMPERATURE MATERIALS - STATUS AND POTENTIAL
R. L. FLEISCHER (GE Research and Development Center, Schenectady, NY), D. M. DIMIDUK (USAF, Wright-Patterson AFB, OH), and H. A. LIPSITT (Wright State University, Dayton, OH) IN: Annual review of materials science. Volume 19. Palo Alto, CA, Annual Reviews, Inc., 1989, p. 231-263. refs
Copyright

Ordered intermetallics are class compounds presenting unique opportunuties for gas turbine hot section component fabrication due to their unusual combinations of lightness and high-temperature strength and/or stiffness. Intermetallics are described as 'ordered' if two or more sublattices are required to describe their atomic structures. The existence of ordered intermetallic compounds arises from the existence of stronger bonds between unlike nearest-neighbor atoms than between like nearest-neighbors. Attention is given to current understanding of Fe3Al, Ni3Al, Ti3Al, Al3Ti, FeAl, NiAl, and TiAl intermetallics. The most successful of these materials are still plagued by excessive creep. O.C.

A90-15214
THE CREEP BEHAVIOR OF THE TI3AL ALLOY TI-24AL-11NB
R. W. HAYES (Metals Technology, Inc., Northridge, CA) Scripta Metallurgica (ISSN 0036-9748), vol. 23, Nov. 1989, p. 1931-1936. Research supported by Metals Technology, Inc.
Copyright

The objective of the study was to evaluate the steady-state creep behavior of the Ti-24Al-11Nb, an alloy currently considered for air breathing jet engine applications. The tests reported here revealed no surface microcracking in specimens tested in air. The activation energy and stress exponent measured for the alloy indicate that power law creep is operative within the temperature (650-760 C) and stress (69-172.35 MPa) range evaluated. The stress level needed for the onset of power law creep in the alloy is substantially lower than in the case of single-phase Ti3Al-base intermetallics. V.L.

A90-15425#
PREDICTING THE CO, HC, AND NO(X) EMISSION AND COMBUSTION EFFICIENCY OF SMALL TURBINE ENGINES FROM THE COMBUSTION CHAMBER BENCH TEST RESULTS [PRZEWIDYWANIE EMISJI CO, HC, NO/X/ I SPRAWNOSCI SPALANIA DLA MALEGO SILNIKA TURBINOWEGO NA PODSTAWIE WYNIKOW STOISKOWYCH BADAN KOMORY SPALANIA]
RYSZARD LAPUCHA Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 114-115, 1988, p. 78-92. In Polish. refs

Bench test results for three evaporative combustion chambers of small turbine engines are compared in terms of CO, HC, and NO(x) emission. For certain mixture ratios, the combustion curves for all the chambers tested are similar. Therefore, bench test results can be used for predicting CO, HC, and NO(x) emission as well as the combustion efficiency of the combustion chambers of small turbines at the design stage. V.L.

A90-15732
DEVELOPMENT OF A REMAINING USEFUL LIFE OF A LUBRICANT EVALUATION TECHNIQUE. III - CYCLIC VOLTAMMETRIC METHODS
R. E. KAUFFMAN (Dayton, University, OH) Lubrication Engineering (ISSN 0024-7154), vol. 45, Nov. 1989, p. 709-716. Research supported by USAF. refs
Copyright

This paper considers a cyclic-voltammetric-based remaining-useful-life-of-a-lubricant evaluation technique (RULLET). It is shown that such technique can be developed on the basis of electrochemical reduction of the original and generated antioxidant species in the oil sample. Compared to the thermal-oxidative and chemical-oxidative RULLET methods reported by Kauffman and Rhine (1988), the cyclic voltammetric method is not limited by its instrumental cost or by the use of hazardous chemicals. The method is easy, requires a small amount of sample, and takes less than one minute to perform. I.S.

N90-11813# Pacific Northwest Lab., Richland, WA.
STOCHASTIC PROPAGATION OF AN ARRAY OF PARALLEL CRACKS: EXPLORATORY WORK ON MATRIX FATIGUE DAMAGE IN COMPOSITE LAMINATES
R. E. WILLIFORD Sep. 1989 37 p
(Contract DE-AC06-76RL-01830)
(DE89-017837; PNL-6903) Avail: NTIS HC A03/MF A01

Transverse cracking of polymeric matrix materials is an important fatigue damage mechanism in continuous-fiber composite laminates. The propagation of an array of these cracks is a stochastic problem usually treated by Monte Carlo methods. However, this exploratory work proposes an alternative approach wherein the Monte Carlo method is replaced by a more closed-form recursion relation based on fractional Brownian motion. A fractal scaling equation is also proposed as a substitute for the more empirical Paris equation describing individual crack growth in this approach. Preliminary calculations indicate that the new recursion relation is capable of reproducing the primary features of transverse matrix fatigue cracking behavior. Although not yet fully tested or verified, this cursion relation may eventually be useful for real-time applications such as monitoring damage in aircraft structures. DOE

N90-11819# Aeritalia S.p.A., Turin (Italy). Lab. Strutture e Ricerche sui Materiali.
CHOICE AND CHARACTERIZATION OF NEW MATERIALS FOR AEROSPACE APPLICATIONS [CARATTERIZZAZIONE E SCELTA DI MATERIALI INNOVATIVI PER IMPIEGHI AEROSPAZIALI]
F. CIPRI 1989 18 p In ITALIAN
(ETN-89-95219) Avail: NTIS HC A03/MF A01

Some results covering mechanical properties of product families used for aircraft structures are reported, and the development of new materials and technology which will be used in aerospace projects are discussed. The criteria followed in the choice of composite materials for the primary structures design of advanced aircraft are detailed. ESA

N90-11820# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli da Combattimento.
A NEW TEST PROCEDURE FOR A WING MADE WITH CARBON FIBER COMPOSITES [UNA NUOVA TECNICA DI PROVA PER UN'ALA IN COMPOSITO DI FIBRA DI CARBONIO]
ERALDO PADOVANO and VINCENZO VALLONE 1989 7 p In ITALIAN
(ETN-89-95220) Avail: NTIS HC A02/MF A01

The testing method applied to full size delta shape half wings of a fighter aircraft is presented. It consists of discrete loading applied by means of hydraulic devices which reproduce the distribution of shear and torque to which the wing is subjected under aerodynamic and inertia loadings. The experimental setup is described. Block diagrams detailing load control and data acquisition are presented. ESA

N90-11821*# Lockheed-California Co., Burbank.
TRANSPORT COMPOSITE FUSELAGE TECHNOLOGY: IMPACT DYNAMICS AND ACOUSTIC TRANSMISSION Final Report
A. C. JACKSON, F. J. BALENA, W. L. LABARGE, G. PEI, W. A. PITMAN, and G. WITTLIN Washington Dec. 1986 163 p
(Contract NAS1-17698)
(NASA-CR-4035; NAS 1.26:4035; LR-31038) Avail: NTIS HC A08/MF A01 CSCL 11/4

A program was performed to develop and demonstrate the impact dynamics and acoustic transmission technology for a composite fuselage which meets the design requirements of a 1990 large transport aircraft without substantial weight and cost penalties. The program developed the analytical methodology for the prediction of acoustic transmission behavior of advanced composite stiffened shell structures. The methodology predicted that the interior noise level in a composite fuselage due to turbulent boundary layer will be less than in a comparable aluminum fuselage. The verification of these analyses will be performed by NASA Langley Research Center using a composite fuselage shell fabricated by filament winding. The program also developed analytical methodology for the prediction of the impact dynamics behavior of lower fuselage structure constructed with composite materials. Development tests were performed to demonstrate that the composite structure designed to the same operating load requirement can have at least the same energy absorption capability as aluminum structure. Author

N90-11837# Argonne National Lab., IL.
ANALYTICAL STUDIES OF THREE-DIMENSIONAL COMBUSTION PROCESSES Final Report, Dec. 1982 - Sep. 1988
S. PRATAP VANKA May 1989 243 p
(Contract FY1455-88-N0617; AF PROJ. 2308)
(AD-A211903; AFWAL-TR-88-2140) Avail: NTIS HC A11/MF A02 CSCL 21/5

This report summarizes the significant contributions from a research program sponsored at Argonne National Laboratory by the Air Force Wright Aeronautical Laboratories, Advanced Propulsion Division. The objectives of this study were to develop advanced computational techniques and physical models for calculating the multidimensional flow and combustion process in subsonic ramjet and ducted rocket configurations. A number of significant accomplishments were made during the course of this study. These include: (1) development of efficient solution techniques for subsonic, elliptic fluid flows; (2) application and assessment of the two-equation turbulence model to swirling and nonswirling flows in a sudden expansion geometry; and (3) analysis of combustion processes in a prototypical ducted rocket configuration. GRA

N90-11872# Aeritalia S.p.A., Turin (Italy).
THE EVOLUTION OF LIGHT ALLOYS IN THE AEROSPACE INDUSTRY [L'EVOLUZIONE DELLE LEGHE LEGGERE NELL'INDUSTRIA AEROSPAZIALE]
G. ARSTENTO, F. BOSCHETTI, and M. SCOLARIS 1987 17 p In ITALIAN Presented at the Convegno Associazione Italiana di Metallurgia, Milan, Italy, 3-5 Nov. 1987
(ETN-89-95216) Avail: NTIS HC A03/MF A01

The characteristics of the light alloys used as aircraft construction materials are compared with those available in the past. Studies on the effect of chemical composition and thermal treatments to improve crack propagation and corrosion resistance characteristics are described. The economic factors considered in selection are discussed. ESA

N90-11874# Rolls-Royce Ltd., Derby (England).
ALUMINIUM ALLOY DEVELOPMENT FOR AERO ENGINES
DAVID DRIVER 1 Sep. 1987 6 p
(PNR90548; ETN-89-95545) Copyright Avail: NTIS HC A02/MF A01

The present and potential uses of different aluminium alloys in making aero engines is discussed. The benefits and drawbacks of aluminum-copper alloys, aluminum-zinc-magnesium alloys, cast aluminum-copper alloys, wrought aluminum-copper alloys and miscellaneous aluminum alloys are presented. The experience of Rolls Royce in testing and using such alloys is discussed. An itemized list of miscellaneous aluminum alloys is given. ESA

N90-11899# Army Belvoir Research and Development Center, Fort Belvoir, VA.
THE PREDICTION OF MIDDLE DISTILLATE FUEL PROPERTIES USING LIQUID CHROMATOGRAPHY-PROTON NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY DATA Final Report, 1987 - 1988
MADELINE SWANN Jun. 1989 60 p
(AD-A211879; BRDEC-2478) Avail: NTIS HC A04/MF A01 CSCL 21/4

The research was initiated to support the Army's capability to identify the components of fuels which contribute to low temperature performance of fuels. It was discovered that various physical properties of middle distillate fuels can be predicted. The

liquid chromatography (LC) H-1 NMR technique was developed to predict physical properties based on chemical structures present in the fuels. The prediction of properties is approached from a group property point of view. In the group property approach, the structure of the molecule is examined for structural features which dictate the physical properties of the compounds. In other words, the physical properties of a molecule or compound are determined by the number of types of chemical groups, i.e., methyl, methylene, methine, etc., present. These LC H-1 NMR predicted property measurements were compared to measurements obtained by the ASTM fuel tests. Most measurements were found to be within experimental error. The research has demonstrated that the LC H-1 NMR approach for measuring various middle distillate fuel properties can be used as an alternative to the ASTM methods of fuel property measurement. GRA

N90-12665# Aeritalia S.p.A., Turin (Italy).
PROJECT, IMPLEMENTATION, AND UTILIZATION OF COMPOSITE STRUCTURES [PROGETTAZIONE, REALIZZAZIONE E IMPIEGO DI STRUTTURE IN COMPOSITO]
L. CASALEGNO 1987 31 p In ITALIAN Presented at a conference, Turin, Italy, 20 Nov. 1987
(ETN-89-95209) Avail: NTIS HC A03/MF A01

The most significant aspects of Aeritalia experience in designing and testing composite structures for aircrafts are described. The materials employed include Kevlar, glass and carbon fibers. The evolution of the mechanical properties of the commercial products is discussed. The software used to optimize the structural design of the composites is detailed. ESA

N90-12667# Rolls-Royce Ltd., Derby (England).
COMPOSITE MATERIALS FOR FUTURE AEROENGINES
G. E. KIRK 4 Jun. 1989 8 p Presented at the ASME Gas Turbine and Aeroengine Congress, Toronto, Ontario, 4-8 Jun. 1989
(PNR90584; ETN-89-95559) Copyright Avail: NTIS HC A02/MF A01

The need for advances in material and manufacturing technology in order that aeroengines can satisfy future market requirements is stressed. The potential of composite materials to meet the increased requirements is discussed. The use of resin composites and further improvements needed in that technology are summarized. The use of metal and ceramic composites where higher temperature capability is required is discussed. Problems that must be solved before these composites can be used to their full potential with confidence are described. ESA

N90-12720# Rolls-Royce Ltd., Derby (England).
THE FUTURE OF NON FERROUS METALS IN AEROSPACE ENGINES
P. J. POSTANS and R. H. JEAL 6 Oct. 1988 11 p Presented at Eurometaux, Luxembourg, 5-6 Oct. 1988
(PNR90572; ETN-89-95554) Copyright Avail: NTIS HC A03/MF A01

Trends in nonferrous metals use in aerospace engines in the past, and future uses of such metals are discussed. Nickel and titanium have played a key role in the continuing improvement of aero engines since the 1940s and 1950s. The 1990s will see these materials being further developed, but they are now approaching the limit of their capabilities. For engines beyond the year 2000, conventional metallic materials will not have sufficient strength, stiffness or temperature capability. The development of reinforced or composite materials with metal, glass or ceramic matrices and concurrent work and appropriate new design and manufacturing technology is called for. ESA

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A90-13750* Akron Univ., OH.
EXPERIMENTAL AND ANALYTICAL EVALUATION OF DYNAMIC LOAD VIBRATION OF A 2240-KW (3000-HP) ROTORCRAFT TRANSMISSION
FRED K. CHOY (Akron, University, OH), DENNIS P. TOWNSEND, and FRED B. OSWALD (NASA, Lewis Research Center, Cleveland, OH) Franklin Institute, Journal (ISSN 0016-0032), vol. 326, no. 5, 1989, p. 721-735. Previously announced in STAR as N87-20556. refs
Copyright

A dynamic analysis of a 2240-kW (3000-hp) helicopter planetary system is presented. Results from both analytical and experimental studies show good correlation in gear-tooth loads. A parametric study indicates that the mesh damping ratio has a significant effect on maximum gear tooth load, stress, and vibration. Correlation with experimental results indicates that the Sun-planet mesh damping ratio can significantly differ from the planet ring mesh damping ratio. A numerical fast Fourier transform (FFT) procedure was applied to examine the mesh load components in the frequency domain and the magnitudes of multiple tooth pass frequencies excited by nonsynchronous meshing of the planets. Effects of tooth-spacing errors and tooth-profile modifications with tip relief are examined. A general discussion of results and correlation with the experimental study are also presented. Author

A90-13767
NUMERICAL SIMULATION OF VALVELESS PULSED COMBUSTORS
J. A. OLORUNMAIYE (Ilorin, University, Nigeria) and J. A. C. KENTFIELD (Calgary, University, Canada) Acta Astronautica (ISSN 0094-5765), vol. 19, Aug. 1989, p. 669-679. refs
(Contract NSERC-A-7928)
Copyright

The paper describes a mathematical model for simulating the cyclic operation of valveless pulsed combustors. The flows in the inlet and tail pipe were assumed to be one-dimensional while the combustion chamber was treated as a large reservoir with uniform thermodynamic properties. The effects of wall friction, heat transfer, gradual area changes, variable entropy and composition changes due to chemical reaction were included in the modeling. The set of first order quasi-linear hyperbolic partial differential equations describing the inlet and tail pipe flows were solved by a numerical method of characteristics. The results predicted with the model are in good agreement with some experimental results. The model showed that intermittent combustion in the combustion chamber is established through variations in the concentrations of carbon dioxide and oxygen. Lower and upper fuel flow rate extinction limits which have been observed experimentally, were found, from the results of the model, to be due to leanness and richness of the fresh charge in the combustion chamber, respectively.
Author

A90-13770
STRUCTURAL OPTIMIZATION OF LIFTING SURFACES WITH DIVERGENCE AND CONTROL REVERSAL CONSTRAINTS
K. B. BOWMAN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), R. V. GRANDHI (Wright State University, Dayton, OH), and F. E. EASTEP (Dayton, University, OH) Structural Optimization (ISSN 0934-4373), vol. 1, Sept. 1989, p. 153-161. refs

(Contract F33615-88-C-3204)
Copyright

In this paper, the static aeroplastic characteristics, divergence velocity, control effectiveness and lift effectiveness are considered in obtaining an optimum weight structure. Swept wing structures are used with upper and lower skins, spar and rib thicknesses, and spar cap and vertical post cross-sectional area as the design parameters. The aerodynamic strip theory is used to derive the constraint formulations and aerodynamic load matrices. A Sequential Unconstrained Minimization Technique (SUMT) algorithm is used to optimize the wing structure to meet the desired aeroelastic constraints. Author

A90-13845#
ENDURANCE OF AIRCRAFT GAS TURBINE MAINSHAFT BALL BEARINGS-ANALYSIS USING IMPROVED FATIGUE LIFE THEORY. II - APPLICATION TO A BEARING OPERATING UNDER DIFFICULT LUBRICATION CONDITIONS
T. HARRIS, M. RAGEN (MRC Bearings, Jamestown, NY), E. IOANNIDES (Imperial College of Science and Technology, London, England), and H. TAM (Pratt and Whitney Canada, Mississauga) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 111, Oct. 1989, p. 708-710.
Copyright

The improved fatigue life theory of Ioannides and Harris (1985) is used to predict the endurance of a small turbine engine mainshaft ball bearing. The duty cycle to which the bearing was subjected is illustrated. It was found that the L(10) fatigue life of the bearing within 95 percent confidence limits should fall between 6250 and 14,800 hrs with a nominal value of 8,950 hrs. K.K.

A90-13995#
THE ROLE OF ADAPTIVE ANTENNA SYSTEMS WHEN USED WITH GPS
ROLF JOHANNESSEN (STC Technology, Ltd., Harlow, England) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 267-270.

The possible effects of jamming on the operation of the GPS is examined, and possible ways of dealing with this problem are discussed. In particular, it is shown that Controlled Reception Pattern Antennas are capable of greatly increasing the jamming levels for which GPS can be used. Nulls of the order of 40 dB can be generated in high dynamic applications. It is expected that such systems will find increased applications in the air, at sea, and on land. V.L.

A90-14006#
SIGNAL PROCESSING IN A DIGITAL GPS RECEIVER
DOMINIC FARMER, STEVEN LEASURE, and JAMES THOMAS (Plessey Avionics, Ltd., Havant, England) IN: ION, Satellite Division's International Technical Meeting, Colorado Springs, CO, Sept. 19-23, 1988, Proceedings. Washington, DC, Institute of Navigation, 1989, p. 387-395.

Some novel approaches to GPS signal acquisition and tracking are examined in the context of the digital signal processing capability of the latest generation of PPS 5-channel GPS receivers. Moding and measurement quality of the GPS sensors are considered in a range of combinations of dynamics and RF interference. The system implications of tracking performance are examined and results from simulations are compared with measured performance. Author

A90-14326* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SCALING EFFECTS IN THE IMPACT RESPONSE OF GRAPHITE-EPOXY COMPOSITE BEAMS
KAREN E. JACKSON (NASA, Langley Research Center; U.S. Army, Army Aviation Research and Technology Activity, Hampton, VA) and EDWIN L. FASANELLA (Planning Research Corp., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 16 p. refs
(SAE PAPER 891014) Copyright

In support of crashworthiness studies on composite airframes and substructure, an experimental and analytical study was conducted to characterize size effects in the large deflection response of scale model graphite-epoxy beams subjected to impact. Scale model beams of 1/2, 2/3, 3/4, 5/6, and full scale were constructed of four different laminate stacking sequences including unidirectional, angle ply, cross ply, and quasi-isotropic. The beam specimens were subjected to eccentric axial impact loads which were scaled to provide homologous beam responses. Comparisons of the load and strain time histories between the scale model beams and the prototype should verify the scale law and demonstrate the use of scale model testing for determining impact behavior of composite structures. The nonlinear structural analysis finite element program DYCAST (DYnamic Crash Analysis of STructures) was used to model the beam response. DYCAST analysis predictions of beam strain response are compared to experimental data and the results are presented. Author

A90-14329
DYNAMIC TESTING OF CRASHWORTHY FUEL VALVES
RUSSELL L. ROGERS (Aeroquip Corp., Jackson, MI) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 4 p.
(SAE PAPER 891017) Copyright

A method for the dynamic testing of crashworthy fuel valves is described which uses the rotary accelerator as a dynamic test device. In particular, attention is given to the modifications required to make the rotary accelerator a safe and reliable test apparatus. These include the addition of a chamber to house the test specimen and its holding fixture, a pair of hammers to strike or catch the anvil, a solenoid system to release the hammers, an anvil, a linkage system to connect the anvil to the test specimen, and a pit in which to catch the separated test specimen. A schematic diagram of the modified rotary accelerator is shown. V.L.

A90-14339
COMPOSITE DRIVESHAFT DESIGNS
SERGE ABRATE (Missouri-Rolla, University, Rolla) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 14 p. refs
(SAE PAPER 891031) Copyright

Composite materials are used to design drive shafts when significant weight savings are sought or when traditional materials can not be used. A satisfactory design produces a transmission for which the total weight, including intermediate supports, is minimized, while satisfying several constraints. First, critical speeds of the shaft should lay outside of the range of operating speeds. This condition limits the unsupported length of the shaft and requires the use of intermediate supports. The second constraint is that the shaft should not buckle under the maximum expected torque. Driveshaft design consists of selecting the number of intermediate supports, the shaft diameter, and wall-thickness. With composites, the choice of fibers and fiber orientation are additional variables to be used for optimization. Author

A90-14347
RESIN TRANSFER MOLDING OF COMPOSITE AIRCRAFT STRUCTURES
MARK WADSWORTH (Wichita State University, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 12 p.
(SAE PAPER 891042) Copyright

Resin transfer molding (RTM) is a process that has been used for manufacturing fiber-glass parts for many years. Renewed interest in RTM has been stimulated by the need for improved producibility in advanced composite manufacture. Recent developments in resins, reinforcement, and automation have made RTM a viable option for manufacturing aircraft structures. The present studies were undertaken to determine the quality and producibility of structures fabricated with this process. A transparent mold was constructed to allow resin flow visualization and modeling of the relationships between processing variables and molding

success. This paper addresses these issues while reviewing the current state of the art in tool design and RTM processing.
Author

A90-14358
THE WARPING RESTRAINT EFFECT IN THE CRITICAL AND SUBCRITICAL STATIC AEROELASTIC BEHAVIOR OF SWEPT FORWARD COMPOSITE WING STRUCTURES
L. LIBRESCU and S. THANGJITHAM (Virginia Polytechnic Institute and State University, Blacksburg) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 12 p. refs
(SAE PAPER 891056) Copyright

An exact approach to the aeroelastic spanwise lift distribution and divergence instability of swept (aft and back) uniform composite wing structures is developed in this paper. The approach based on the Laplace transform technique enables one to solve in a unified manner both aeroelastic problems. The analysis encompasses the cases of free and restrained warping models for the wing twist. Numerical results are finally presented to demonstrate the effects played by the fiber orientation, ply lay-up, warping restraint and wing geometry both on the subcritical static aeroelastic response and on the divergence instability of composite swept wings.
Author

A90-14360
AEROSPACE STRUCTURES SUPPORTABILITY
HOWARD WESLEY SMITH (Kansas, University, Lawrence) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 9 p. refs
(SAE PAPER 891058) Copyright

This paper is about supportability in its general sense, with emphasis on aerospace structures. Reliability and maintainability (R&M) are described and defined from the standpoint of both structural analysis. Accessability, inspectability, and replaceability are described as design attributes. Reliability and probability of failure are shown to be in the domain of the analysis. Availability and replaceability are traditional logistic responsibilities which are influenced by supportability engineers. The USAF R&M 2000 process is described, and the R&M 1988 Workshop at Wright-Patterson Air Force Base is also included in the description.
Author

A90-14363
ELECTROCHROMIC WINDOWS - APPLICATIONS FOR AIRCRAFT
CAROLINE S. HARRIS and CHARLES B. GREENBERG (PPG Industries, Inc., Pittsburgh, PA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 6 p. refs
(SAE PAPER 891063) Copyright

A transparent, solid-state, electrochromic device is described. It demonstrates deep switching in the near infrared and visible spectral regions and good room temperature cycling stability. The response appears reasonably uniform over a 14 cm x 28 cm area, which gives hope for achieving large parts for cockpit and cabin windows. The reversible darkening of the transparency, controlled by an applied voltage or current, has potential application in aircraft to reduce glare and solar heat load to pilots and passengers. The active material in the device is a thin tungsten oxide film which is incorporated into a complex, multilayered structure, essentially that of a transparent battery. The performance of the window is discussed in terms of its configuration, its similarities with commercial batteries and issues critical to aircraft.
Author

A90-14557
STRESS-STRAIN ANALYSIS OF STRUCTURAL ELEMENTS OF INCOMPRESSIBLE OR NEARLY INCOMPRESSIBLE MATERIALS BY THE FINITE ELEMENT METHOD [K RASCHETU NAPRIAZHENNO-DEFORMIROVANNOGO SOSTOIANIIA ELEMENTOV KONSTRUKTSII IZ NESZHIMAEMYKH ILI POCHTI NESZHIMAEMYKH MATERIALOV METODOM KONECHNYKH ELEMENTOV]
M. IU. AL'ES, V. K. BULGAKOV, and A. M. LIPANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 10-13. In Russian.
Copyright

An iterative finite element algorithm is proposed for calculating the stress-strain state of structural elements made of incompressible or nearly incompressible materials. The algorithm makes it possible to obtain a stable converging solution for any (physically permissible) value of the Poisson coefficient and to substantially reduce the order of the initial system of finite element equations. To illustrate the efficiency and robustness of the algorithm proposed here, some results of numerical and analytical solutions are presented for a hollow circular cylinder under plane strain conditions.
V.L.

A90-14558
NONLINEAR TRANSVERSE OSCILLATIONS OF A COMPOSITE DYNAMIC SYSTEM [NELINEINYE POPERECHNYE KOLEBANIIA SOSTAVNOI DINAMICHESKOI SISTEMY]
B. A. ANTUF'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 13-17. In Russian.
Copyright

An approximate solution is presented for the problem of nonlinear transverse oscillations of two composite dynamic systems. The solution represents a generalization of the dynamic compliance method to the case of finite-amplitude system oscillations. As an example, equations are obtained and lower natural frequencies are determined for a flexible shallow spherical shell hinged to a flexible beam at two points.
V.L.

A90-14560
DYNAMIC ANALYSIS OF LIFTING SURFACES OF SMALL RELATIVE THICKNESS IN THE CASE OF FINITE DISPLACEMENTS [O DINAMICHESKOM RASCHETE NESUSHCHIKH POVERKHNOSTEI MALOI OTNOSITEL'NOI TOLSHCHINY PRI KONECHNYKH PEREMESHCHENIIAKH]
V. G. GAINUTDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 19-23. In Russian. refs
Copyright

An algorithm is presented for the dynamic analysis of flexible lifting surfaces modeled by thin and thin-walled rods as well as lifting surfaces described by more complex models. Attention is given to lifting surfaces of large and moderate aspect ratios and lifting surfaces whose cross sections move like rigid disks under deformation. Equations of motion are obtained for the case of finite displacements, and an example of calculations is presented.
V.L.

A90-14565
THE METHOD OF MATCHED INTEGRAL REPRESENTATIONS IN VISCOUS FLUID DYNAMICS [METOD SRASHCHIVAEMYKH INTEGRAL'NYKH PREDSTAVLENII V DINAMIKE VIAZKOI ZHIDKOSTI]
IU. A. KRASHANITSA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 38-41. In Russian.
Copyright

A solution for the external first boundary value problem for a system of Navier-Stokes equations is obtained in the form of integral representations of the velocity vector and stress tensor components, whose intensities are determined numerically from a system of linear boundary integral and finite equations. The algorithm proposed here and the results of calculations can be used directly in the aerodynamic design of flight vehicles and their components.
V.L.

A90-14574
A STUDY OF THE NONLINEAR DEFORMATION OF A SHELL OF REVOLUTION WITH A SURFACE BEND [ISSLEDOVANIE NELINEINOGO DEFORMIROVANIIA OBOLOCHKI VRASHCHENIIA S IZLOMOM POVERKHNOSTI]
V. V. KUZ'MIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 71-73. In Russian. refs
Copyright

The nonlinear deformation of a shell of revolution with a surface

bend is investigated analytically using the discrete energy approach. By using this approach, parallel solutions are obtained on the basis of two geometrically nonlinear theories: the Mushtari-Vlasov-Donnel theory and the Novozhilov-Sanders theory. The deformation behavior of a spherical tank with a radial cylindrical pipe is calculated as an example, and the accuracy of the results is evaluated. V.L.

A90-14585
THERMODYNAMIC CALCULATION OF THE COMPRESSORS OF GAS TURBINE ENGINES AND POWERPLANTS AT HIGH AIR PRESSURES [*TERMODINAMICHESKII RASCHET KOMPRESSOROV GAZOTURBINNYKH DVIGATELEI I USTANOVOK PRI VYSOKIKH STEPENIAKH POVYSHENIIA DAVLENIIA VOZDUKHA*]
V. P. DOBRODEEV and A. P. NOSKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 94-96. In Russian. refs
Copyright

For compressed air pressures higher than 2-2.5 MPa, it is important that the pressure dependence of the thermodynamic properties of air be taken into account. Here, formulas are presented for calculating the density, enthalpy, entropy, isobaric and isochoric specific heats, isentropy index, and sound velocity with allowance for pressure. The thermodynamic parameters calculated on the basis of these formulas are the same as the values calculated by the exact method for pressures up to 30 MPa and agree with the exact results to within 1 percent at pressures up to 100 MPa. V.L.

A90-15045
THE PROPAGATION OF A NORMAL SHOCK IN A VARYING AREA DUCT
A. SURESH (Sverdrup Technology, Inc., Middleburg Heights, OH) IN: Recent advances in engineering science; Proceedings of the A. Cemal Eringen Symposium, Berkeley, CA, June 20-22, 1988. Berlin and New York, Springer-Verlag, 1989, p. 179-187. refs
Copyright

Chisnell's law gives the change in strength of a shock propagating into a varying area duct with gas at rest. This paper presents an extension of this law to the case where an isentropic flow exists ahead of the moving shock wave. Using Whitham's (1958) approach, an analytic expression is derived for the change in strength of the shock wave. When conditions ahead of the shock wave are quiescent, the expression reduces to Chisnell's law. The amplification factor obtained in this case is significantly different from Chisnell's law and changes sign as the flow Mach number ahead of the shock wave goes from subsonic to supersonic. C.D.

A90-15354
CARBON FIBRE COMPOSITE BOLTED JOINTS
L. A. BURNET (British Aerospace, PLC, Warton, England) IN: Design in composite materials; Proceedings of the IME Conference, London, England, Mar. 7, 8, 1989. Bury Saint Edmunds, England, Mechanical Engineering Publications, Ltd., 1989, p. 61-67.
Copyright

This paper aims to give an introduction to the design of composite bolted joints at British Aerospace. Basic failure modes and the effects of geometric and lay-up variations are discussed. Codes of design practice to ensure optimum joint design are presented. The most common joint occurring in aircraft structures is a countersunk fastener in single shear. Results from programs investigating the static and fatigue response of such joints as a function of laminate thickness and fastener type are presented. Finally, the two methods of stressing bolted joints under combined loading are discussed. The first method is applied to relatively lightly-loaded joints using small fasteners, e.g. wing skin/spar bolting. The second is applied to highly loaded joints using large fasteners, e.g. wing/fuselage attachment. Author

A90-15355
EXPERIMENTAL STUDY ON THE BUCKLING AND POSTBUCKLING OF CARBON FIBRE COMPOSITE PANELS WITH AND WITHOUT INTERPLY DISBONDS
G. B. CHAI, W. M. BANKS, and J. RHODES (Strathclyde, University, Glasgow, Scotland) IN: Design in composite materials; Proceedings of the IME Conference, London, England, Mar. 7, 8, 1989. Bury Saint Edmunds, England, Mechanical Engineering Publications, Ltd., 1989, p. 69-85. Research supported by ESA and Ministry of Defence. refs
Copyright

An extensive experimental investigation is extended from the work of Rajan and Banks, et al, on the effect of prescribed interply delaminations on the postbuckling strength of carbon fiber (Grafil XAS/914C Fibredux) composite panels. The test setup gave simply supported boundary conditions on the unloaded edges and fully fixed conditions on the loaded ends. The work was completed with a view to the possible structural exploitation of the postbuckling strength of carbon fiber composite panels and to investigate the possible structural degradation due to the adverse effect of interply delaminations. The details of the experimental tests and their results are presented, and the significance of the work is emphasized. Author

A90-15357
THE ADVANTAGES OF AUTOMATION IN AEROSPACE PRODUCTION
G. W. HUGHES (British Aerospace, PLC, Blackburn, England) IN: Design in composite materials; Proceedings of the IME Conference, London, England, Mar. 7, 8, 1989. Bury Saint Edmunds, England, Mechanical Engineering Publications, Ltd., 1989, p. 115-118.
Copyright

Composite components have been manufactured for aircraft for several years. The main application today is for carbon fiber/epoxy resin composites. In the early days of manufacturing the challenge was to manufacture parts of suitable quality to almost any cost. With increasing production volumes and the increasing pressure on costs of both civil and military aircraft programs the emphasis has shifted significantly to one of minimizing costs. An attractive candidate approach is the introduction of automation. This paper investigates various alternative automation options for manufacturing and concludes that the introdution of some plant can be extremely cost-effective. However, care must be taken as some means of automation on offer are not worthy of investment on purely cost grounds. Author

A90-15387
HEAT TRANSFER AND FLUID MECHANICS INSTITUTE, 31ST, CALIFORNIA STATE UNIVERSITY, SACRAMENTO, JUNE 1, 2, 1989, PROCEEDINGS
FREDERICK H. REARDON, ED. and DINH THINH, ED. (California State University, Sacramento) Sacramento, CA, California State University, 1989, 427 p. For individual items see A90-15388 to A90-15394.
Copyright

The present conference discusses the large-eddy simulation of pressure oscillations and combustion instabilities in a ramjet, injection-process modelling for a regenerative liquid-propellant gun, a generalized approach to one-dimensional internal gas dynamics, viscous flow in simple curved gaps, a circular combustor configuration with multiple injection ports for mixing enhancement, and a computer-controlled self-aligned hot-wire anemometer. Also considered are the unified modeling of porous media, the permeability of alumina for several gases with small complex media, a simple wake-expansion model for horizontal axis wind turbines, secondary and turbulent flow in a wavy duct, and in situ measurements of rock thermophysical properties and site characterization. O.C.

A90-15389* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A CIRCULAR COMBUSTOR CONFIGURATION WITH MULTIPLE INJECTION PORTS FOR MIXING ENHANCEMENT

B. GHORASHI, K. CHUN, P. KANG, and R. NEIDZWECKI (NASA, Lewis Research Center, Cleveland, OH) IN: Heat Transfer and Fluid Mechanics Institute, 31st, Sacramento, CA, June 1, 2, 1989, Proceedings. Sacramento, CA, California State University, 1989, p. 39-57. refs
Copyright

A circular combustor design by Ghorashi (1988) which resembles a continuously-stirred tank reactor with multiple injection ports is presented with a view to the enhanced control of mixing, NO(x) reduction, and combustion efficiency maximization. Attention is given to the prototype apparatus for this type of circular combustor, which takes the form of a transparent cold-flow reactor for flow visualization studies under 'chemically frozen' conditions. O.C.

A90-15393
A MODEL FOR THE ELECTROHYDRODYNAMIC FLOW IN A CONSTRICTED ARC HEATER
KENNETH K. MURAMOTO (Acurex Corp., Mountain View, CA) IN: Heat Transfer and Fluid Mechanics Institute, 31st, Sacramento, CA, June 1, 2, 1989, Proceedings. Sacramento, CA, California State University, 1989, p. 153-173. Research supported by the Acurex Corp. refs
Copyright

The electrohydrodynamic flow in a constricted arc heater is analyzed using a theoretical model which employs an explicit finite-difference technique for solving the governing conservation equations and auxiliary relations. The numerical procedure consists of a forward-marching process starting from assumed inlet profiles and prescribed wall boundary conditions. The results of the analyses indicate that the exit solution does not depend strongly upon the inlet profiles for constrictors having length-to-diameter ratios greater than 20 and that an increase in turbulent mixing throughout the constrictor results in higher values of the arc voltage and the mass-averaged gas enthalpy at the exit. It is shown that very accurate predictions of overall arc heater performance can be obtained by using a algebraic turbulence model that is a function of the inlet Reynolds number. Author

A90-15878#
LABORATORY ANALYSIS OF ANTIWEAR PROPERTIES OF TURBINE-ENGINE FUELS [LABORATORYJNA OCENA WLASCIWOSCI PRZECIWZUZYCIOWYCH PALIW DO SILNIKOW TURBINOWYCH]
ZBIGNIEW KIERSZKO (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 44, April 1989, p. 10, 18, 19. In Polish.

Methods for analyzing the antiwear properties of turbine-engine fuels are described. The methods considered are based on the examination of fuel adsorption on metal surfaces and on friction force measurements. B.J.

A90-15887
THE PRODUCTION OF UNIFORMLY SHEARED STREAMS BY MEANS OF DOUBLE GAUZES IN WIND TUNNELS - A MATHEMATICAL ANALYSIS
S. L. V. COELHO (Cambridge, University, England) Experiments in Fluids (ISSN 0723-4864), vol. 8, no. 1-2, Oct. 1989, p. 25-32. Research supported by CNPq. refs
Copyright

The use of gauzes for the production of uniformly sheared streams in wind tunnels is examined. An analysis of results obtained with single gauzes shows that the poor theoretical evaluations of the shear rate reported in the literature seem to be related to the different empirical expressions for the lift coefficient. Streams with uniform shear rate can only be obtained with single gauzes when high drag screens are used, with the disadvantage of producing large scale turbulent motion downstream from the gauze. As an alternative, a theoretical analysis of the flow through double gauzes of uniform porosity leads to a useful method of designing gauzes for specific shear rates of high intensity. The results of the analysis indicate that the use of a set of several gauzes of low resistance is an optimal method for producing high shear rates with low turbulence intensities. V.L.

A90-15900
COMPLEMENTARY FIELD METHOD FOR INTERFEROMETRIC TOMOGRAPHIC RECONSTRUCTION OF HIGH SPEED AERODYNAMIC FLOWS
SOYOUNG S. CHA and HONGWEI SUN (Illinois, University, Chicago) Optical Engineering (ISSN 0091-3286), vol. 28, Nov. 1989, p. 1241-1246. Research supported by the U.S. Army. refs
Copyright

A complementary field method has been devised for interferometric tomographic reconstruction of high-speed aerodynamic flows involving a shock. It is based on the reconstruction of the complementary field, which is the difference between the object field to be reconstructed and its estimate. The method is iterative in nature and incorporates a priori information. This study demonstrates advantages of the method in alleviating the deficiencies associated with computational reconstructors and measured data. Substantial reconstruction improvement is obtained, especially near a shock when its position is utilized as a priori information. Under the test conditions, convergence of the method is rapid. Author

A90-16003#
A NOVEL METHOD OF ATOMIZATION WITH POTENTIAL GAS TURBINE APPLICATIONS
ARTHUR H. LEFEBVRE (Purdue University, West Lafayette, IN) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 353-361.

In conventional airblast or air-assist nozzles the bulk liquid to be atomized is first transformed into a jet or sheet before being exposed to the atomizing air. In the method of atomization described in this paper, the air is introduced into the bulk liquid at some point upstream of the nozzle discharge orifice. This injected air forms bubbles which 'explode' downstream of the injection orifice thereby shattering the liquid into small drops. Experiments carried out on this atomizer, using water as the working fluid and nitrogen as the driving gas, show that good atomization can be achieved using only small amounts of atomizing gas at injection pressures as low as 173 kPa (25 psi). It is found that atomization quality is largely independent of the size of the nozzle discharge orifice. Thus, the system appears to have good potential for applications where small holes and passages cannot be employed due to the risk of blockage by contaminants in the fuel. Author

A90-16011#
CREEP-FATIGUE INTERACTIONS OF GAS TURBINE MATERIALS
TARUN GOSWAMI (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 467-475. refs

The military aircraft gas turbine engines are often required to undergo a complex set of operating conditions where the load varies considerably with respect to time. The temperature range for performing such requirements also increases as the thrust increases. The modern design of gas turbine demands very high thrust-to-weight ratio. In order to achieve this, the design is limited in the low-cycle regime. The low-cycle regime necessarily has the plasticity effect because of fatigue and inelastic time-dependent permanent deformation because of creep. Fatigue and creep interaction studies are very important for the safe life design of critical components such as turbine disks and blades. Author

A90-16012#
DIFFUSION BONDING AEROENGINE COMPONENTS
G. A. FITZPATRICK and T. BROUGHTON (Rolls-Royce, PLC, Colne, England) Defence Science Journal (ISSN 0011-748X), vol. 38, Oct. 1988, p. 477-485.

The use of diffusion bonding processes at Rolls-Royce for the manufacture of titanium-alloy aircraft engine components and structures is described. A liquid-phase diffusion bonding process called activated diffusion bonding has been developed for the

manufacture of the hollow titanium wide chord fan blade. In addition, solid-state diffusion bonding is being used in the manufacture of hollow vane/blade airfoil constructions mainly in conjunction with superplastic forming and hot forming techniques. B.J.

A90-16320
RECENT STUDIES ON THE BEHAVIOUR OF INTERFERENCE FIT PINS IN COMPOSITE PLATES
T. S. RAMAMURTHY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Composite Structures (ISSN 0263-8223), vol. 13, no. 2, 1989, p. 81-99. refs
Copyright

Composites are finding increasing application in many advanced engineering fields like aerospace, marine engineering, hightech sports equipment, etc., due to their high specific strength and/or specific stiffness values. The use of composite components in complex situations like airplane wing root or locations of concentrated load transfer is limited due to the lack of complete understanding of their behavior in the region of joints. Joints are unavoidable in the design and manufacture of complex structures. Pin joints are one of the most commonly used methods of connection. In regions of high stresses like airplane wing root joints, interference fit pins are used to increase its fatigue life and thereby increase the reliability of the whole structure. The present contribution is a study on the behavior of the interference fit pin in a composite plate subjected to both pull and push type of loads. The interference fit pin exhibits partial contact/separation under the loads and the contact region is a nonlinear function of the load magnitude. This nonlinear behavior is studied by adopting the inverse technique and some new results are presented in this paper. Author

A90-16371*# Rensselaer Polytechnic Inst., Troy, NY.
SHAFT FLEXIBILITY EFFECTS ON AEROELASTIC STABILITY OF A ROTATING BLADED DISK
NAIM KHADER (Jordan University of Science and Technology, Irbid) and ROBERT LOEWY (Rensselaer Polytechnic Institute, Troy, NY) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Nov.-Dec. 1989, p. 718-726. Research supported by Jordan University of Science and Technology. refs
(Contract NAG3-37)
Copyright

A comprehensive study of Coriolis forces and shaft flexibility effects on the structural dynamics and aeroelastic stability of a rotating bladed-disk assembly attached to a cantilever, massless, flexible shaft is presented. Analyses were performed for an actual bladed-disk assembly, used as the first stage in the fan of the 'E3' engine. In the structural model, both in-plane and out-of-plane elastic deformation of the bladed-disk assembly were considered relative to their hub, in addition to rigid disk translations and rotations introduced by shaft flexibility. Besides structural coupling between blades (through the flexible disk), additional coupling is introduced through quasisteady aerodynamic loads. Rotational effects are accounted for throughout the work, and some mode shapes for the whole structure are presented at a selected rpm. Author

A90-16372#
NONINTERFERENCE BLADE-VIBRATION MEASUREMENT SYSTEM FOR GAS TURBINE ENGINES
WILLIAM B. WATKINS (United Technologies Corp., Government Engine Business, West Palm Beach, FL) and RAY M. CHI (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 5, Nov.-Dec. 1989, p. 727-730. Previously cited in issue 20, p. 3231, Accession no. A87-45186.
(Contract F33657-79-C-0730)
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A90-16616
THE MANUFACTURE OF SPF MILITARY AIRCRAFT DOORS IN ALUMINIUM ALLOY
G. W. HUGHES, S. H. JOHNSTON, and B. GINTY (British Aerospace, PLC, Aircraft Group, Preston, England) IN: Superplasticity and superplastic forming; Proceedings of the International Conference, Blaine, WA, Aug. 1-4, 1988. Warrendale, PA, Minerals, Metals and Materials Society, 1988, p. 643-648. refs
Copyright

SPF/DB titanium is a proven production technology at BAe. Until recently SPF of aluminium alloys has been confined to secondary and tertiary aircraft structures due to the lack of a suitable structural alloy. Project studies have indicated that useful cost and weight savings can be achieved by the application of SPF aluminium to various military aircraft primary structure components. The development of high strength 7475E and 8090 SPF aluminum alloys offers the potential of manufacturing such structures. The objectives of achieving manufacturing cost savings and weight benefits have been verified through design and manufacture of the L/H module door for Tornado. The subsequent scale-up manufacture of a large complex S shaped SPF 8090 EAP main undercarriage door has also been demonstrated. This paper discusses the manufacture of the Tornado door. Author

A90-16618
PRODUCTION OF TI6AL4V-COMPONENTS FOR A NEW TURBO-FAN-ENGINE
R. FURLAN, P.-J. WINKLER (MBB GmbH, Munich, Federal Republic of Germany), D. HAGG, and L. REISINGER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) IN: Superplasticity and superplastic forming; Proceedings of the International Conference, Blaine, WA, Aug. 1-4, 1988. Warrendale, PA, Minerals, Metals and Materials Society, 1988, p. 665-677.
Copyright

A superplastic forming process for the fabrication of Ti6Al4V alloy components for new turbofan engines is described. In particular, attention is given to the redesign and retooling required for the process, the use of ceramic stop-off materials, and a hot die technique. Changes in the microstructure of the material during the process and the effect of superplastic forming on the static and dynamic strengths of the components are discussed. V.L.

A90-16619
STUDY ON SPF AND SPF/DB OF THE BULK-HEAD STRUCTURE WITH NONSYMMETRIC SHAPE
YOU-QIN LI and SHI-LING ZHANG (Beijing Aeronautical Manufacturing Technology Research Institute, People's Republic of China) IN: Superplasticity and superplastic forming; Proceedings of the International Conference, Blaine, WA, Aug. 1-4, 1988. Warrendale, PA, Minerals, Metals and Materials Society, 1988, p. 679-683.
Copyright

This paper describes the research result of a Ti-6Al-4V bulkhead structure with a nonsymmetric shape and notches accessed by stringers produced by superplastic forming (SPF) and superplastic forming/diffusion bonding (SPF/DB). The paper includes the selection of SPF method; the forming method and process; the thickness distribution of parts and their homogeneity; SPF/DB method and coordination problems, and finally, the feasibility of producing complicated nonsymmetric structures by SPF and SPF/DB. The research result has been applied in aviation industry. Author

A90-16620
DB/SPF COOLER OUTLET DUCT FOR AIRCRAFT APPLICATION
W. BECK (MBB GmbH, Bremen, Federal Republic of Germany) IN: Superplasticity and superplastic forming; Proceedings of the International Conference, Blaine, WA, Aug. 1-4, 1988. Warrendale, PA, Minerals, Metals and Materials Society, 1988, p. 685-697. refs
Copyright

Different SPF/DB methods have been analyzed to fabricate a cooler outlet duct. The development is successfully finished.

Component and DB/SPF process are certified. Series production has started. Cost and weight savings have been realized as predicted. Author

N90-11907# Michigan Technological Univ., Houghton.
IMPROVING SNOW ROADS AND AIRSTRIPS IN ANTARCTICA Final Report, Nov. 1986 - Jun. 1988
SUNG M. LEE, WILBUR M. HAAS, ROBERT L. BROWN, and ALBERT F. WUORI Jul. 1989 24 p Sponsored by NSF, Washington, DC
(AD-A211588; CRREL-SP-89-22) Avail: NTIS HC A02/MF A01 CSCL 08/12

During the 1986 to 1987 austral summer, snow road and runway test lanes were constructed at McMurdo Station and at South Pole Station. These lanes were monitored during Dec. 1986 to Jan. 1987, and again in Jan. 1988. Test sections were constructed of: (1) tractor-compacted snow topped with a 15 cm layer of rotary blower processed snow, (2) rotary processed and compacted snow in 15-cm layers to a depth of 60 cm, (3) rotary processed and compacted snow in 15-cm layers incorporating wood sawdust additive mixed at 5 percent by volume, and (4) rotary-processed snow with 10 percent sawdust by volume. These test sections were monitored by obtaining temperature and density profiles, Rammsonde hardness profiles, California Bearing Ratio and Clegg surface strength values, and testing for ability to withstand traffic. Wood sawdust added to processed snow in amounts of 5 to 10 percent by volume significantly increases the strength of the resulting snow road or runway. Adequate strengths of the snow/sawdust mixtures were achieved for limited use by wheeled C130 aircraft, but additional processing with heat, water or added compaction appears necessary to produce a 25-cm-thick surface layer adequate for frequent use and to accommodate wheeled C141 aircraft. At McMurdo, it was found that the sawdust was not effective in maintaining the integrity of the surface traffic during the thawing season without additional maintenance, whereas at the South Pole, thawing was not a problem since temperatures remained well below the melting point. GRA

N90-11908# Army Cold Regions Research and Engineering Lab., Hanover, NH.
ICE RUNWAYS NEAR THE SOUTH POLE Special Report
CHARLES SWITHINBANK Jun. 1989 47 p
(Contract MIPR-CRREL-89-12)
(AD-A211606; CRREL-SR-89-19) Avail: NTIS HC A03/MF A01 CSCL 01/5

Following an examination of air photographs of the Transantarctic Mountains, 37 blue-ice areas were reconnoitered from the air, using a ski-wheel Twin Otter operating from the South Pole. Two sites were selected as potential airfields for conventional transport aircraft, and ground surveys were made. On the Mill Glacier at 85 deg 06'S, 167 deg 15'E there is an area of smooth and level ice which gives a 7-km run directly into the prevailing wind. Five wheel landings were made there. Alongside Mount Howe there is a large area of level ice at 87 deg 20'S, 149 deg 50'W. It offers a 7-km runway, but there is a strong crosswind component from the prevailing wind and some bumps on the ice surface need to be planed off. Eight wheel landings were made at Mount Howe. GRA

N90-11934# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
ASR-9 WEATHER CHANNEL TEST REPORT
DEAN C. PUZZO, SETH W. TROXEL, MARK A. MEISTER, MARK E. WEBER, and JAMES V. PIERONEK 3 May 1989 140 p
(Contract F19628-85-C-0002; DTFA01-80-Y-10546)
(AD-A211749; ATC-165; DOT/FAA/PS-89-3) Avail: NTIS HC A07/MF A01 CSCL 17/9

The ASR-9, the next generation airport surveillance radar, will be deployed by the FAA at over 100 locations throughout the U.S. The system includes a weather channel designed to provide ATC personnel with timely and accurate weather reflectivity information as a supplement to normal aircraft information. Issues addressed are: whether the ASR-9 weather channel performs according to FAA specifications and whether the ASR-9 weather channel adequately represents weather reflectivity for ATC purposes. Comparisons between data from an ASR-9 in Huntsville, AL, recorded during design qualification and testing, and data from two other reference radars, were used as the basis for the assessment. Several storm cases were analyzed, comprised of stratiform rain, isolated convective storms, squall lines, and cold fronts containing multiple simultaneous convective storms. Results suggest that, with the exception of an apparent 3 dB discrepancy between the weather products of the ASR-9 and the reference radars, the ASR-9 weather channel seems to perform according to FAA specifications. Although the ASR-9 products give a reasonable representation of the extent and severity of potentially hazardous weather in Huntsville, the results suggest that the static storm model used to determine beamfill corrections for the ASR-9 should be optimized for the particular climatic region in which an ASR-9 will be operated. GRA

N90-11970*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION OF GLANCING SHOCK WAVE AND BOUNDARY LAYER INTERACTION
CHING-MAO HUNG Sep. 1989 13 p Presented at the 8th GAMM Conference, Delft, The Netherlands, 27-29 Sep. 1989
(NASA-TM-102233; A-89241; NAS 1.15:102233) Avail: NTIS HC A03/MF A01 CSCL 20/4

Shock waves generated by sharp fins, glancing across a laminar boundary layer growing over a flat plate, are simulated numerically. Several basic issues concerning the resultant three-dimensional flow separation are studied. Using the same number of grid points, different grid spacings are employed to investigate the effects of grid resolution on the origin of the line of separation. Various shock strengths (generated by different fin angles) are used to study the so-called separated and unseparated boundary layer and to establish the existence or absence of the secondary separation. The usual interpretations of the flow field from previous studies and new interpretations arising from the present simulation are discussed. Author

N90-11982# Pennsylvania State Univ., University Park. Applied Research Lab.
AN INVESTIGATION OF END-WALL VORTEX CAVITATION IN A HIGH REYNOLDS NUMBER AXIAL-FLOW PUMP
KEVIN J. FARRELL Aug. 1989 182 p Sponsored by Naval Sea Systems Command
(AD-A211426; ARL/PSU/TR-89-004) Avail: NTIS HC A09/MF A01 CSCL 20/4

Relative motion of a turbomachinery blade row and the casing requires finite clearance between the rotor tips and the end-wall to avoid rubbing. Presence of this gap, relative motion of the blade tip and the end-wall, and pressure difference across the blade give rise to tip clearance flow which causes many adverse effects, including end-wall vortex cavitation. The vortex is formed by interaction of the clearance flow with the through flow on the suction side of the blade. This report formulates a correlation of the appropriate variables which predict the inception of end-wall vortex cavitation using the following approach: (1) identification of necessary parameters and relationships; (2) experimental measurements of the parameters in the High Reynolds Number Pump facility, a 42-inch diameter pump specifically designed for this purpose; (3) formulation of the correlation model from relationships among the measured variables; and (4) verification of the model with existing databases. The resulting model provides guidance to turbomachinery designers. The model of end-wall vortex cavitation successfully correlates the subject data existing databases. An optimum tip clearance was theoretically identified. The correlation model contains the boundary layer, lift coefficient, tip clearance, vortex core size, and tip geometry as input variables. Submodels have been developed for the core radius and tip lift coefficient as a function of tip clearance. Laser velocimeter measurements shown that additional circulation is shed into the tip vortex form the suction side trailing edge. GRA

N90-11988# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
EXPERIMENTAL RESEARCH ON SWEPT SHOCK WAVE/BOUNDARY LAYER INTERACTIONS Final Report, 1 Apr. 1986 - 31 Mar. 1989
GARY S. SETTLES 28 Jun. 1989 43 p
(Contract AF-AFOSR-0082-86; AF PROJ. 2307)
(AD-A211744; PSU-ME-R-88/89-0068; AFOSR-89-1055TR)
Avail: NTIS HC A03/MF A01 CSCL 20/4

An experimental research effort on the subject of swept shock wave interactions with turbulent boundary layers is reported. The research relied largely on nonintrusive, laser based optical flow diagnostics. Experiments were carried out to define the Mach number influence, flowfield structure, and quantitative skin friction behavior of fin generated swept interactions over the supersonic range from March 2.5 to 4.0, including weak, moderate, and strong interactions. The results have given new insight into the fin interaction flowfield structure, which involves a jet impingement process caused by shockwave bifurcation. High skin friction levels were measured in the vicinity of this jet impingement and were used for the validation of computational predictions carried out by others. GRA

N90-12007# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abteilung Flugversuchstechnik.
DEVICES AND PROCEDURES FOR THE CALIBRATION OF SENSORS AND MEASUREMENT: SYSTEMS OF THE FLIGHT TEST SUPPORT SYSTEM ATTAS
RUDOLF OLIVA and DIETER OTTO Dec. 1988 94 p In GERMAN; ENGLISH summary
(DFVLR-MITT-89-06; ISSN-0176-7739; ETN-89-95297; AD-B134983L) Avail: NTIS HC A05/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 50 DM

A detailed description of devices used in the calibration of sensors of the flight test support system ATTAS (Advanced Technologies Testing Aircraft System) is presented. The devices were developed and manufactured by the Flight Test Engineering Division of the Institute for Flight Mechanics. The installation of the devices and calibration procedures are described. Proposals for improvement of calibration devices and procedures are discussed. ESA

N90-12035# Aeritalia S.p.A., Turin (Italy). Gruppo Velivoli da Combattimento.
IN SERVICE LIFE MONITORING SYSTEM USING G-METER READINGS AND MASS CONFIGURATION CONTROL
T. GIACOBBE 1987 16 p Presented at the Associazione Italiana per la Fatica in Aeronautica, Milan, Italy, 16-17 Mar. 1987
(ETN-89-95218) Avail: NTIS HC A03/MF A01

The Interim Monitoring System (IMS) is described. This system is based on the g meter readings and allows it to know the fatigue life consumed, before the utilization of the maintenance recorder system. The fatigue life consumption is considerably lower than the theoretical one, if the contractual maneuver spectrum is applied. (The ratio between contractual flight hours and actual flight hours is about 0.25). The results are comparable to those employing Tornado. The usefulness of the system, related to the true life consumption and not to the flight hours, is stressed. ESA

N90-12042*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EFFECT OF CONTROL SURFACE MASS UNBALANCE ON THE STABILITY OF A CLOSED-LOOP ACTIVE CONTROL SYSTEM
E. NISSIM (Technion - Israel Inst. of Tech., Haifa.) Oct. 1989 26 p
(NASA-TP-2952; H-1534; NAS 1.60:2952) Avail: NTIS HC A03/MF A01 CSCL 20/11

The effects on stability of inertial forces arising from closed-loop activation of mass-unbalanced control surfaces are studied analytically using inertial energy approach, similar to the aerodynamic energy approach used for flutter suppression. The limitations of a single control surface like a leading-edge (LE) control or a trailing-edge (TE) control are demonstrated and compared to the superior combined LE-TE mass unbalanced system. It is shown that a spanwise section for sensor location can be determined which ensures minimum sensitivity to the mode shapes of the aircraft. It is shown that an LE control exhibits compatibility between inertial stabilization and aerodynamic stabilization, and that a TE control lacks such compatibility. The results of the present work should prove valuable, both for the purpose of flutter suppression using mass unbalanced control surfaces, or for the stabilization of structural modes of large space structures by means of inertial forces. Author

N90-12057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRFRAME STRUCTURAL DYNAMIC CONSIDERATIONS IN ROTOR DESIGN OPTIMIZATION
RAYMOND G. KVATERNIK and T. SREEKANTA MURTHY (Planning Research Corp., Hampton, VA.) Aug. 1989 27 p
(NASA-TM-101646; NAS 1.15:101646) Avail: NTIS HC A03/MF A01 CSCL 20/11

An an overview and discussion of those aspects of airframe structural dynamics that have a strong influence on rotor design optimization is provided. Primary emphasis is on vibration requirements. The vibration problem is described, the key vibratory forces are identified, the role of airframe response in rotor design is summarized, and the types of constraints which need to be imposed on rotor design due to airframe dynamics are discussed. Some considerations of ground and air resonance as they might affect rotor design are included. Author

N90-12058*# Textron Bell Helicopter, Fort Worth, TX.
INVESTIGATION OF DIFFICULT COMPONENT EFFECTS ON FINITE ELEMENT MODEL VIBRATION PREDICTION FOR THE BELL AH-1G HELICOPTER. VOLUME 1: GROUND VIBRATION TEST RESULTS
R. V. DOMPKA Oct. 1989 212 p
(Contract NAS1-17496)
(NASA-CR-181916-VOL-1; NAS 1.26:181916-VOL-1) Avail: NTIS HC A10/MF A02 CSCL 20/11

Under the NASA-sponsored Design Analysis Methods for VIBrationS (DAMVIBS) program, a series of ground vibration tests and NASTRAN finite element model (FEM) correlations were conducted on the Bell AH-1G helicopter gunship to investigate the effects of difficult components on the vibration response of the airframe. Previous correlations of the AH-1G showed good agreement between NASTRAN and tests through 15 to 20 Hz, but poor agreement in the higher frequency range of 20 to 30 Hz. Thus, this effort emphasized the higher frequency airframe vibration response correlations and identified areas that need further R and T work. To conduct the investigations, selected difficult components (main rotor pylon, secondary structure, nonstructura doors/panels, landing gear, engine, fuel, etc.) were systematically removed to quantify their effects on overall vibratory response of the airframe. The entire effort was planned and documented, and the results reviewed by NASA and industry experts in order to ensure scientific control of the testing, analysis, and correlation exercise. In particular, secondary structure and damping had significant effects on the frequency response of the airframe above 15 Hz. Also, the nonlinear effects of thrust stiffening and elastomer mounts were significant on the low frequency pylon modes below main rotor 1p (5.4 Hz). The results of the ground vibration testing are presented. Author

N90-12777# Naval Research Lab., Washington, DC. Chemistry Div.
AVIATION ENGINE TEST FACILITIES (AETF) FIRE PROTECTION STUDY Interim Report, Apr. 1986 - Apr. 1987
R. C. BELLER, R. E. BURNS (Hughes Associates, Inc., Wheaton MD.), and J. T. LEONARD 13 Jul. 1989 118 p
(AD-A211483; NRL-MR-6505) Avail: NTIS HC A06/MF A01 CSCL 01/3

An analysis is presented to the effectiveness of various types

of fire fighting agents in extinguishing the kinds of fires anticipated in Aviation Engine Test Facilities (AETF), otherwise known as Hush Houses. The agents considered include Aqueous Film-Forming Foam, Halon 1301, Halon 1211 and water. Previous test work has shown the rapidity with which aircraft, especially high performance aircraft, can be damaged by fire. Based on this, tentative criteria for this evaluation included a maximum time of 20 s from fire detection to extinguishment and a period of 30 min in which the agent would prevent reignition. Other issues examined included: toxicity, corrosivity, ease of personnel egress, system reliability, and cost effectiveness. The agents were evaluated for their performance in several fire scenarios, including: under frame fire, major engine fire, engine disintegration fire, high-volume pool fire with simultaneous spill fire, internal electrical fire, and runaway engine fire. GRA

N90-12778# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
ROLLING OF ARALL LAMINATES (AN ALTERNATIVE METHOD FOR POST-STRETCHING ARALL LAMINATES)
D. CHEN, F. E. H. M. SMULDERS, and L. B. VOGELESANG Jul. 1988 23 p
(LR-560; ETN-89-95606) Avail: NTIS HC A03/MF A01

A rolling process is presented as an alternative to post stretching aramide reinforced aluminum laminates (ARALL) in order to set fibers under tension and the aluminum layers under compression. It is found that the reversion of the thermal residual stress system in ARALL laminates can easily be achieved by rolling the material to a permanent setting (for instance 0.4 percent). The fatigue properties of the material are as good as the post-stretched version and some of the mechanical properties show significant improvement without losing any advantage. The main advantage of this process is that conventional rolling equipment can be used which means lower costs and higher productivity for the materials manufacturer. The process may be used to treat wide panels which is essential if the ARALL laminates are to be used as aircraft fuselage skin materials. Test results are presented. ESA

N90-12781# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
AIRCRAFT REPLY AND INTERFERENCE ENVIRONMENT SIMULATOR (ARIES) HARDWARE PRINCIPLES OF OPERATION. VOLUME 2: APPENDIXES
EDWARD MANCUS Oct. 1989 131 p
(DOT/FAA/CT-TN88/4-2) Avail: NTIS HC A07/MF A01

The Aircraft Reply and Interference Environment Simulator (ARIES) makes possible the performance assessment of the Mode Select (Mode S) sensor under its specific maximum aircraft load. To do this, ARIES operates upon disk files for traffic model and interference to generate simulated aircraft replies and fruit, feeding them to the sensor at radio frequency. Support documentation for ARIES consists of: (1) ARIES Hardware Maintenance Manual: Volume 1 (DOT/FAA/CT-TN88/3); (2) Appendixes of the Hardware Maintenance Manual: Volume 2; (3) ARIES Hardware Principles of Operation: Volume 1 (DOT/FAA/CT-TN88/4); (4) Appendices of the Hardware Principles of Operation: Volume 2; (5) ARIES Software Principles of Operation (DOT/FAA/CT-TN87/16); and (6) ARIES Software User's Manual (DOT/FAA/CT-TN88/15). The Appendices to the Hardware Principles of Operation provide: (1) the acronyms and abbreviations used within the document; (2) detailed information covering the development and implementation of controller microcode; and (3) uplink receiver digital alignment. Author

N90-12782# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
AIRCRAFT REPLY AND INTERFERENCE ENVIRONMENT SIMULATOR (ARIES) HARDWARE PRINCIPLES OF OPERATION, VOLUME 1
EDWARD MANCUS Oct. 1989 276 p
(DOT/FAA/CT-TN88/4-1) Avail: NTIS HC A13/MF A02

The Aircraft Reply and Interference Environment Simulator (ARIES) makes possible the performance assessment of the Mode Select (Mode S) sensor under its specific maximum aircraft load. To do this, ARIES operates upon disk files for traffic model and interference to generate simulated aircraft replies and fruit, feeding them to the sensor at radio frequency. Support documentation for ARIES consists of: (1) the ARIES Hardware Maintenance Manual: Volume 1 (DOT/FAA/CT-TN88/3); (2) Appendixes of the Hardware Maintenance Manual: Volume 2; (3) the ARIES Hardware Principles of Operation: Volume 1 (DOT/FAA/CT-TN88/4-1); (4) Appendixes of the Hardware Principles of Operation: Volume 2; (5) ARIES Software Principles of Operation (DOT/FAA/CT-TN87/16); and (6) ARIES Software User's Manual (DOT/FAA/CT-TN88/15). This document, the ARIES Hardware Principles of Operation, Volume 1, explains the theory of operation of the ARIES special purpose hardware designed and fabricated at the Federal Aviation Administration Technical Center. Each hardware device is discussed. Functional block diagrams, signal timing diagrams, and state timing diagrams are included where appropriate. Author

N90-12807 Civil Aviation Authority, London (England). Air Traffic Control Evaluation Unit.
ASSESSMENT OF VOICE CODERS FOR ATC/PILOT VOICE COMMUNICATIONS VIA SATELLITE DIGITAL COMMUNICATION CHANNELS
N. L. TROLL Mar. 1989 34 p Original contains color illustrations
(Contract DEPE(CNA)-PROJ. EU650)
(CAA-PAPER-89004; REPT-550; ETN-89-95248) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England

An Air Traffic Control (ATC) simulation testbench constructed for the purpose of assessing the use of voice coding equipment (vocoders) for relaying voice communications between air traffic controllers and pilots via satellite digital communication channels is described. The development of the testbench and the analysis procedures is described. Several vocoders employing different coding algorithms which have been proposed for use over satellite data channels are assessed. Within the limitations imposed by the simulation, the assessment suggests that voice coded speech at 8 to 9.6 k bit/sec would be acceptable for some ATC tasks. The assessment results were also used to rank the vocoders for acceptability to support ATC voice communications under various bit error rates over the digital communication channel. ESA

N90-12816# Royal Signals and Radar Establishment, Malvern (England).
FINE RESOLUTION ERRORS IN SECONDARY SURVEILLANCE RADAR ALTITUDE REPORTING AMONGST AIRCRAFT TRANSMITTING THE CONSPICUITY CODES 4321 AND 4322
P. BANKS, B. A. WYNDHAM, and D. B. JENKINS Jun. 1988 13 p Sponsored by the Civil Aviation Authority, London, England
(RSRE-88004; BR108924; ETN-89-94834) Copyright Avail: NTIS HC A03/MF A01

The incidence of Secondary Surveillance Radar (SSR) mode C pressure altitude encoding faults are examined. It is caused by stuck/shorted C bits, investigated amongst aircraft transmitting the SSR mode A conspicuity codes 4321 and 4322. The 6808 aircraft trajectories are studied. The 152 trajectories displayed C bit faults on the SSR mode C replies. The proportion of SSR plots bearing conspicuity codes is found to vary with geographical location and time. The measured frequency for similar mode C faults and the presently measured frequencies of SSR plots mode C faults for conspicuity code aircraft are compared. The results show the overall frequency for stuck/shorted C bit faults ranging 0.49 percent for the airspace covered by the Civil Aviation Authority Heathrow tower radar to 0.70 percent for similar equipment. ESA

N90-12823 Physics and Electronics Lab. TNO, The Hague (Netherlands).
AIRCRAFT SAR SIMULATION SARGEN 1.0
M. P. G. OTTEN 8 Feb. 1989 66 p
(FEL-1989-44; TD89-0953; ETN-89-94994) Copyright Avail:

TNO Physics and Electronics Lab., P.O. Box 96864, 2509 JG The Hague, Netherlands

An aircraft Synthetic Aperture Radar (SAR) simulation program which generates raw data (Sargen) is described. The purpose of the simulation is to investigate the effects of unwanted aircraft motions on SAR imaging. Deliberate maneuvering is not included. Both range and azimuth compressed data are considered. The range compression itself is assumed, not simulated. The azimuth compression, which is needed to form the image is not part of Sargen. The aircraft motion is specified by discrete time sequences of three position and three attitude variables. Validation runs are done, including image formation with existing azimuth compression algorithms. The observed effects corresponded to theoretical approximations. ESA

N90-12872*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.

A COMPUTATIONALLY EFFICIENT MODELLING OF LAMINAR SEPARATION BUBBLES Semiannual Status Report, Jan. - Jun. 1989

PAOLO DINI and MARK D. MAUGHMER 1989 15 p

(Contract NAG1-778)

(NASA-CR-185854; NAS 1.26:185854) Avail: NTIS HC A03/MF A01 CSCL 20/4

In order to predict the aerodynamic characteristics of airfoils operating at low Reynolds numbers, it is necessary to accurately account for the effects of laminar (transitional) separation bubbles. Generally, the greatest difficulty comes about when attempting to determine the increase in profile drag that results from the presence of separation bubbles. While a number of empirically based separation bubble models have been introduced in the past, the majority assume that the bubble development is fully predictable from upstream conditions. One way of accounting for laminar separation bubbles in airfoil design is the bubble analog used in the design and analysis program of Eppler and Somers. A locally interactive separation bubble model was developed and incorporated into the Eppler and Somers program. Although unable to account for strong interactions such as the large reduction in suction peak sometimes caused by leading edge bubbles, it is able to predict the increase in drag and the local alteration of the airfoil pressure distribution that is caused by bubbles occurring in the operational range which is of most interest. E.R.

N90-12879# Helsinki Univ. of Technology, Espoo (Finland). Lab. of Aerodynamics.

SOLUTION OF THE THIN-LAYER NAVIER-STOKES EQUATIONS FOR LAMINAR TRANSONIC FLOW

TIMO SIIKONEN and JAAKKO HOFFREN 28 Feb. 1989 60 p

(PB89-221600; SER-A-89-A11; ISBN-951-754-855-9) Avail: NTIS HC A04/MF A01 CSCL 20/4

A finite-volume-based numerical method for the solution of the thin-layer Navier-Stokes equations is presented. The convective part of the fluxes is solved using a flux-vector splitting method and the diffusive part is solved using central differences. The equations are integrated in time with an approximately factored bidiagonal scheme. Convergence is accelerated by applying a multigrid technique. Results are presented for laminar transonic flows over a NACA 0012 airfoil. GRA

N90-12889# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.

REDUCTION OF TURBULENT DRAG: BOUNDARY LAYER MANIPULATORS Final Report [REDUCTION DE TRAINEE DE FROTTEMENT TURBULENT: MANIPULATEURS DE COUCHE LIMITE]

E. COUSTOLS Mar. 1989 55 p In FRENCH

(CERT-RSF-OA-74/2259-AYD; DERAT-59/5004.25; ETN-89-95714) Avail: NTIS HC A04/MF A01

The drag reduction on airbus profiles is investigated. External and internal boundary layer manipulators are applied. The wind tunnel wall geometry and the model surface geometry are modified, carving riblets in the sense of the main flow. The change induced in the flow are studied using hotwire anemometry and spectral analysis. Direct drag measurements on Airbus profiles indicate a drag reduction of 3.5 percent. Experiments using cylindrical bodies in transonic flow show a drag reduction of 8 percent. ESA

N90-12897# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.

TRANSITION IN SURFACE BOUNDARY LAYERS Final Report [TRANSITION DE LA COUCHE LIMITE]

D. ARNAL, F. VIGNAU, and J. C. JUILLEN Feb. 1989 32 p In FRENCH

(Contract DRET-84-002)

(CERT-RSF-OA-43/5018-AYD; DERAT-43/5018.29; DERAT-43/5018.30; ETN-89-95279) Avail: NTIS HC A03/MF A01

Transition from laminar to turbulent flow at the boundary layer at supersonic speeds is investigated. Techniques of maintaining laminar flow by aspiration are described. Theoretical two dimensional flow models are proposed. Experimental results of airfoil tests are provided. The maintenance of laminar flow by aspiration proves to be much more difficult to achieve in practice than the theoretical model suggests. This is due to the difficulty of determining the speed of flow perpendicular to the airfoil. ESA

N90-12899# Air Force Armament Lab., Eglin AFB, FL. Aerodynamics Branch.

UNSTEADY THREE-DIMENSIONAL THIN-LAYER NAVIER STOKES SOLUTIONS ON DYNAMIC BLOCKED GRIDS Final Report, Aug. 1986 - Dec. 1988

L. BRUCE SIMPSON May 1989 157 p

(AD-A212377; AFATL-TR-89-19) Avail: NTIS HC A08/MF A01 CSCL 20/4

An efficient scheme for calculating steady and unsteady solutions on blocked grids for several airfoils and wings is presented. Two algorithms are presented, both of which are based on upwind, finite-volume, flux splitting for the convective terms, and an explicit treatment of the diffusive terms. The first algorithm is based on a flux difference split (FDS) scheme. The two algorithms are compared for steady thin-layer Navier-Stokes solutions on a laminar flat plate, RAE 2822 airfoil, and the ONERA M6 wing. The FDS scheme proved to be superior to the FVS in all cases, due to the excessive numerical dissipation in the FVS scheme. A flat plate laminar boundary layer profile is shown with the FDS scheme correctly modeling the boundary layer (compared to a Blasius solution) with only three grid cells internal to the boundary layer; the FVS scheme was not capable of correctly modeling the boundary layer profile. The FDS algorithm was used to evaluate the scheme for unsteady viscous calculations. The diffusive terms are time-lagged in the solution process and therefore are treated as source terms to the convective terms, which behave as a hyperbolic set of equations. The scheme is second order accurate in space and first order accurate in time due to the explicit treatment of the diffusive terms. A Newton subiteration technique was implemented to allow for larger time step sizes and second order temporal accuracy. GRA

N90-12933# Rolls-Royce Ltd., Derby (England).

THE NATURE AND CONTROL OF SKIDDING IN LIGHTLY LOADED INTERSHAFT BEARINGS

K. V. BLANCHARD and G. A. HALLS 17 May 1989 17 p Presented at the I. Mech. E. Aerospace Bearing Technology, Solihull, England, 17 May 1989

(PNR90591; ETN-89-95563) Copyright Avail: NTIS HC A03/MF A01

The dynamics of skid failure in the intershaft mainline bearing of an aero gas turbine engine are described. The test rig and research program are outlined. The effects of axial load, radial load, shaft speeds, oil flow and shaft and cage out of balance are analyzed in terms of their effect on skid failure of the bearing. A solution to the skidding problem using case out of balance is

presented. The solution is demonstrated on the test rig and substantiated by service records. ESA

N90-12954# Aeritalia S.p.A., Turin (Italy).
FATIGUE BEHAVIOR OF SPECIMENS UNDER COMPRESSION LOAD SPECTRA [COMPORTAMENTO A FATICA DI PROVINI INTAGLIATI SOTTOPOSTI A SPETTRO PREVALENTEMENTE IN COMPRESSIONE]
F. STAROPOLI 1987 18 p In ITALIAN Presented at the Associazione Italiana per la Fatica in Aeronautica, Milan, Italy, 16-17 Mar. 1987
(ETN-89-95207) Avail: NTIS HC A03/MF A01

The fatigue behavior of the Al-7075-T73 aluminum alloy used in structural elements of the Tornado aircraft is studied. The goal was to understand cracks developed on the upper skin panel of the aircraft, in regions of high stress concentration. The load spectra were mainly compression loads, and the specimens were designed for high stress concentration factor. The analysis of the cracks confirms the hypothesis that crack propagation will cease on exit from the high Kt region. ESA

N90-12958# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
AN INVESTIGATION ON COMBINED EXTENSION AND BENDING OF THIN SHEETS WITH A CENTRAL CRACK
D. CHEN Aug. 1988 39 p
(LR-561; ETN-89-95607) Avail: NTIS HC A03/MF A01

An engineering method for predicting fracture behavior of thin metal sheets in combined extension and bending stress conditions using a new testing method called curvature effect testing system (CETS) is described. This method may contribute to a better understanding of the effects of the bending moment in the aircraft fuselage skin introduced by bending the skin sheets elastically from a flat condition into a curved condition during the assembly process. An improved fracture criteria for combined extension and bending of thin sheet is outlined. The bulge-out phenomenon is discussed. ESA

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

N90-12113# National Center for Atmospheric Research, Boulder, CO. Atmospheric Technology Div.
MEETING REVIEW: THE SECOND NCAR (NATIONAL CENTER FOR ATMOSPHERIC RESEARCH) RESEARCH AIRCRAFT FLEET WORKSHOP
WARREN B. JOHNSON and WILLIAM A. COOPER May 1989 94 p Workshop held in Boulder, CO, 15-16 Apr. 1987; sponsored by NSF
(Contract NSF ATM-87-09659)
(PB89-200901; NCAR/TN-332-PROC) Avail: NTIS HC A05/MF A01 CSCL 04/1

A workshop was held at NCAR 15 to 16 April 1987 to assess the scientific needs for atmospheric research aircraft in the next 15 years, and to recommend how the composition of the NCAR aircraft fleet should evolve to meet those needs. The workshop was attended by approximately 75 atmospheric and oceanic scientists and research managers representing all of the scientific areas served by the NCAR Research Aviation Facility. The NCAR group that planned the workshop recognized that the products of the meeting would be most credible and valuable if they reflected the viewpoints of a representative cross section of scientists from a broad spectrum of disciplines and interests, and accordingly prepared the invitation list to provide the needed balance and breadth. The workshop followed up on a previous meeting (the First NCAR Research Aviation Facility Fleet Workshop) that was held in February 1982 with similar purposes. Author

N90-13005# Royal Signals and Radar Establishment, Malvern (England).
A REAL-TIME WIND MODEL USING DIGITAL DATA FROM AIRCRAFT
M. F. WORSLEY and A. J. HUGHES 28 Jul. 1989 25 p Sponsored by the Civil Aviation Authority, London, England
(RSRE-MEMO-4309; BR111666; ETN-89-94869) Copyright Avail: NTIS HC A03/MF A01

An approach to modeling upper atmospheric winds is described. The input data is obtained automatically from aircraft via a digital data link. A statistical method is used to combine the observational data. The realization of the one-dimensional implementation of the model is shown. The results of operating this model in real time are presented. The input data is obtained during ascents and descents of flights effectuated on January 10th and 11th 1989. ESA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-14561
SYNTHESIS OF LOCALLY OPTIMAL AIRCRAFT CONTROL IN THE PRESENCE OF DELAY [SINTEZ LOKAL'NO-OPTIMAL'NOGO UPRAVLENIIA LA PRI NALICHII ZAPAZDYVANIIA]
G. L. DEGTIAREV and S. A. TERENT'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 23-27. In Russian. refs Copyright

The paper is concerned with the problem of control synthesis for systems with delay under conditions of indeterminacy. It is shown that, as in the case of systems without delay, the control synthesis problems for systems with delay include the following two problems: the problem of synthesis of an optimal linear observer and the deterministic problem of synthesis of an optimal controller. Details of the analytical procedure are given. V.L.

A90-14573
DESIGN OF A LANGUAGE FOR THE TESTING OF AIRCRAFT ENGINES [PROEKTIROVANIE IAZYKA ISPYTANII AVIATSIONNYKH DVIGATELEI]
IU. V. KOZHEVNIKOV and I. A. ZALIAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 66-70. In Russian. Copyright

The paper is concerned with the problem of the development of a problem-oriented language for the man-machine interaction in the dialog mode during the testing of aircraft engines using a computerized testing system. An approach to language design is proposed which is based on the principles of matrix decomposition, language unification, and parametric adaptability. An example of the design of a fragment of the testing language is presented. V.L.

A90-14576
PARAMETRIC SYNTHESIS OF PIECEWISE CONSTANT LOCALLY OPTIMAL AIRCRAFT CONTROL UNDER CONDITIONS OF INDETERMINACY [PARAMETRICHESKII SINTEZ KUSOCHNO-POSTOIANNOGO LOKAL'NO-OPTIMAL'NOGO UPRAVLENIIA LA V USLOVIIAKH NEOPREDELENNOSTI]

A. V. BAGINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 75-78. In Russian.
Copyright

A method for the synthesis of piecewise constant aircraft control in the case of incomplete information on the initial state of the aircraft, perturbations, and measurement errors is proposed which uses ellipsoidal estimates of the indeterminacy regions. Control is formulated as a certain linear function of the measured variables containing measurement errors. A closed system of equations is obtained for determining the control law coefficients. V.L.

A90-14587
THE TAPE METHOD FOR THE AUTOMATIC PARTITIONING OF AN ARBITRARY REGION WHEN CALCULATING TEMPERATURE STRESSES [LENTOCHNYI SPOSOB AVTOMATICHESKOGO RAZBIENIIA PROIZVOL'NOI OBLASTI PRI RASCHETE TEMPERATURNYKH NAPRIAZHENII]
V. A. KUDINOV, V. F. PEN'KOV, L. F. CHERNIAEVA, and G. M. SINIAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 3, 1989, p. 98-100. In Russian. refs
Copyright

Temperature stresses in the cooled blades of gas turbines are often calculated by using the Birger-Malinin formula. It is shown that this approach can be advantageously used in conjunction with the tape method of automatic partitioning, which is less time-consuming and more flexible than other partitioning techniques used in finite element analysis. To demonstrate the method, the partitioning of a doubly connected region is carried out as an example. V.L.

A90-14744*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATION MODEL-BUILDING PROCEDURE FOR DYNAMIC SYSTEMS INTEGRATION
P. DOUGLAS ARBUCKLE, CAREY S. BUTTRILL (NASA, Langley Research Center, Hampton, VA), and THOMAS A. ZEILER (Planning Research Corp., Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Nov.-Dec. 1989, p. 894-900. Previously cited in issue 21, p. 3473, Accession no. A87-49169. refs
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A90-14799*# George Washington Univ., Washington, DC.
COMPUTERS BOOST STRUCTURAL TECHNOLOGY
AHMED K. NOOR (George Washington University, Washington, DC) and SAMUEL L. VENNERI (NASA, Materials and Structures Div., Washington, DC) Aerospace America (ISSN 0740-722X), vol. 27, Nov. 1989, p. 30-32 (3 ff.).
Copyright

Derived from matrix methods of structural analysis and finite element methods developed over the last three decades, computational structures technology (CST) blends computer science, numerical analysis, and approximation theory into structural analysis and synthesis. Recent significant advances in CST include stochastic-based modeling, strategies for performing large-scale structural calculations on new computing systems, and the integration of CST with other disciplinary modules for multidisciplinary analysis and design. New methodologies have been developed at NASA for integrated fluid-thermal structural analysis and integrated aerodynamic-structure-control design. The need for multiple views of data for different modules also led to the development of a number of sophisticated data-base management systems. For CST to play a role in the future development of structures technology and in the multidisciplinary design of future flight vehicles, major advances and computational tools are needed in a number of key areas. C.E.

N90-12208# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Unternehmensbereich Drehfluegler.
GENERAL DATA PROCESSING SUPPORT FROM PROJECT PLANNING TO WORKSHOP CONTROL [DURCHGAENGIGE DV-UNTERSTUETZUNG VON DER PROJEKTIERUNG BIS ZU WERKSTATTSTEUERUNG]
DIERK MINKE Dec. 1987 33 p In GERMAN
(MBB-UD-526/88-PUB; ETN-89-94619) Avail: NTIS HC A03/MF A01

The data processing support in aeronautics and space programs from the first idea to the construction is illustrated by a practical example from the field of aircraft development. The iterative process of development, optimization and permission of highly loaded aircraft components is depicted. The organization of the construction of the prototype, resulting from the development phase, and the implementation of data processing systems are described. The use of data processing systems is most meaningful in the domains of planning, administration, and feedback information of orders. A concept for the integration of standard software packages is presented. ESA

N90-12239# Massachusetts Inst. of Tech., Cambridge. Microsystems Research Center.
SEQUENTIAL DESIGN OF EXPERIMENTS WITH PHYSICALLY BASED MODELS 23 M.S. Thesis
MICHELE E. STORM May 1989 82 p
(Contract MDA972-88-K-0008)
(AD-A211918; VLSI-MEMO-89-529) Avail: NTIS HC A05/MF A01 CSCL 12/1

The application of physically based models to sequential optimization was explored and the benefits measured by comparison to optimizations performed using control variable polynomial models. The optimization algorithm developed is based on the sequential use of local (weighted) linear regression models. A new operating point or design is recommended at the optimum of the model within the region where the model is considered valid. This region, within which extrapolations based on the model are believed to be sufficiently accurate, is defined by constraints based on the estimated predictive error of the model and the distance from the data. A new model is created after each data point is collected. As a test case, the sequential optimizer was applied to the design of a paper helicopter for maximum time of flight. The physically based model of the paper helicopter was developed through the use of dimensional analysis, a technique which groups variables according to their dimensions. It was found that the physically based model improved the design of the helicopter more rapidly than the polynomial models. For example, in one comparison of the physical model and the linear model, the physical model reached the optimum design after four sequential designs, while the linear model hadn't reached the optimum after ten designs. GRA

N90-13116# Helsinki Univ. of Technology, Espoo (Finland). Lab. of Aerodynamics.
MULTIGRID SOLUTION METHOD FOR THE EULER EQUATIONS
TIMO SIIKONEN and JAAKKO HOFFREN 12 Jan. 1989 41 p
(PB89-219463; SER-A-89-A10; ISBN-951-754-766-8) Avail: NTIS HC A03/MF A01 CSCL 12/1

A multigrid method for the two-dimensional Euler equations is described. The spatial discretization is based on the flux vector splitting of Van Leer. A finite volume form of the equations is used. Time integration is performed with an approximately factored implicit scheme. Convergence rate is enhanced by a multigrid algorithm. Results are presented for subsonic, transonic and supersonic flows over two airfoil sections. GRA

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A90-13847
COMPOSITE-EMBEDDED OPTICAL FIBERS FOR COMMUNICATION LINKS
R. E. MORGAN, V. V. MITKUS, K. J. JONES, and R. L. HIXSON (U.S. Navy, Naval Avionics Center, Indianapolis, IN) SAMPE Journal (ISSN 0091-1062), vol. 25, Nov.-Dec. 1989, p. 24-27. refs
Copyright

A design concept is examined in which fiber optics embedded in a composite material for avionics packaging will serve as communication links (rather than as stress sensors as in so called 'smart skins/structures'). Attention is given to the material processing technologies, optical fibers, connectors, and composite materials suitable for this purpose. It is emphasized that embedded optical fibers will make it possible to increase signal throughput and the security from EMI/EMP, and will become part of the avionic structure without affecting its shape and volume (or significantly increase its weight). I.S.

A90-14340* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A REVIEW AND UPDATE OF THE NASA AIRCRAFT NOISE PREDICTION PROGRAM PROPELLER ANALYSIS SYSTEM
ROBERT A. GOLUB (NASA, Langley Research Center, Hampton, VA) and L. CATHY NGUYEN (Planning Research Corp., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 14 p. refs
(SAE PAPER 891032) Copyright

The National Aeronautics and Space Administration (NASA) Aircraft Noise Prediction Program (ANOPP) Propeller Analysis System (PAS) is a set of computational modules for predicting the aerodynamics, performance, and noise of propellers. The ANOPP PAS has the capability to predict noise levels for propeller aircraft certification and produce parametric scaling laws for the adjustment of measured data to reference conditions. A technical overview of the prediction techniques incorporated into the system is presented. The prediction system has been applied to predict the noise signature of a variety of propeller configurations including the effects of propeller angle of attack. A summary of these validation studies is discussed with emphasis being placed on the wind tunnel and flight test programs sponsored by the Federal Aviation Administration (FAA) for the Piper Cherokee Lance aircraft. A number of modifications and improvements have been made to the system and both DEC VAX and IBM-PC versions of the system have been added to the original CDC NOS version. Author

A90-14346* Kansas Univ., Lawrence.
BLADE SURFACE PRESSURE MEASUREMENT ON A PUSHER PROPELLER IN FLIGHT
S. FAROKHI and M. VERTZBERGER (Kansas, University, Lawrence) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 11-13, 1989. 12 p. refs
(Contract NAG1-867)
(SAE PAPER 891040) Copyright

Unsteady aerodynamics of a pusher propeller operating in the wake of a pylon is investigated through analysis of flight test data. Twenty-two surface-mounted miniature pressure transducers were installed at the 75 and 90 percent radius locations on a propeller blade on a test-bed aircraft. Twenty-six different flight conditions were flown to cover the range of speeds, rpm, altitudes, and flap positions encountered by an advanced turboprop general aviation aircraft. Preliminary analysis of the flight test data indicate a strong three-dimensionality to the perturbed flow at the 75 and 90 percent radii due to pylon wake encounter. Time-history of the pressure transducer waveforms recorded for 700 revolutions exhibit a one-per-cycle wave oscillation on the wake signature. No explanation is found for this behavior yet. Author

A90-15568
DYNAMIC DAMPING OF VIBRATIONS IN MECHANICAL SYSTEMS BY MEANS OF ELASTIC LINKS WITH DISTRIBUTED PARAMETERS [DINAMICHESKOE GASHENIE KOLEBANII V MEKHANICHESKIKH SISTEMAKH S POMOSHCH'IU UPRUGIKH ZVEN'EV S RASPREDELENNYMI PARAMETRAMI]
F. D. BAIRAMOV (Kamskii Politekhnicheskii Institut, Naberezhnyye Chelny, USSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 25, Oct. 1989, p. 125-127. In Russian.
Copyright

For a mechanical system consisting of a rigid (main) structure and elastic links with distributed parameters, the problem of the damping of the forced vibrations of the harmonically loaded main structure by means of elastic links is stated and solved. It is shown that the resolvability of the problem depends on the coincidence of one of the natural frequencies of the elastic links with the frequency of the excitation force. The damping of the vibrations of an aircraft wing carrying a pair of elastic elements is analyzed as an example. V.L.

A90-16330#
AIRFOIL NOISE IN A UNIFORM FLOW
P. GARCIA (Eli-Echappement, Messei, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1989, p. 1-7. Research supported by DRET. refs
Copyright

An experimental analysis was made of the noise radiated by a NACA 0012 airfoil in a uniform flow in the CEPRA 19 anechoic wind tunnel. The investigations concerned the estimate of the radiated noise from existing theories developed in particular by Chandiramani, Chase and Howe. They required experimental characterization of the pressure field induced by the turbulent boundary layer in the trailing edge region of the airfoil. This work is original in that it allows the noise to be predicted from wave number spectrum measurements made using a sensor array. The prediction is not limited to low frequencies as is the case for computations using the measured integral scales of Corcos. This approach was also applied to airfoils at an incidence. Author

N90-12291# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
NOISE DATA OF FOUR SMALL PROPELLER-DRIVEN AIRPLANES
G. J. J. RUIJGROK and D. M. VANPAASSEN Aug. 1988 39 p (PB89-216980; LR-544) Avail: NTIS HC A03/MF A01 CSCL 20/1

Maximum observed noise levels in terms of dBA are presented for four typical small propeller-driven airplaines. The data are derived from the results of inflight noise recordings taken by the Faculty of Aerospace Engineering of Delft University of Technology. Maximum levels versus distance as a function of powersetting are given wherever possible. GRA

N90-12524*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REMOTE DETECTION OF BOUNDARY-LAYER TRANSITION BY AN OPTICAL SYSTEM
ROBERT M. HALL, MEDHAT AZZAZY, and DARIUSH MODARRESS (Spectron Development Labs., Inc., Costa Mesa, CA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 381-388 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 20/6

This instrument development program was funded because of the urgent need to measure boundary-layer transition in wind tunnels. In the course of this development program, a prototype was designed, built, and tested. Recent transonic experiments in

the Boeing Model Transonic Wind Tunnel show that the interferometer results correlate very well with sublimating chemical tests. Author

N90-12538*# PRC Kentron, Inc., Hampton, VA.
NEAR-FIELD NOISE PREDICTIONS OF AN AIRCRAFT IN CRUISE
JOHN W. RAWLS, JR. *In* NASA, Langley Research Center, Research in Natural Laminar Flow and Laminar-Flow Control, Part 2 p 617-636 Dec. 1987
Avail: NTIS HC A15/MF A02 CSCL 20/1

The physics of the coupling of sound waves with the boundary layer is not yet well understood. It is believed, however, that for effective coupling of the sound waves and instability waves in the boundary layer, a matching of both frequency and wave number must occur. This requires that the sound field be accurately defined in both space and time. Currently analytical prediction methods lack sufficient accuracy to predict the noise levels from components of a turbofan engine. Although empirical methods do not yield the detail required for an analysis of the receptivity of sound by a boundary layer, valuable insight can be gained as to the changes in noise levels that might be expected under various operating conditions and aircraft configurations. Author

N90-12553*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF ACOUSTIC SOURCES
JAMES A. SCHOENSTER and MICHAEL G. JONES (PRC Kentron, Inc., Hampton, VA.) *In its* Research in Natural Laminar Flow and Laminar-Flow Control, Part 3 p 914-921 Dec. 1987
Avail: NTIS HC A17/MF A03 CSCL 20/1

An experiment was conducted to determine the effect of acoustics on the laminar flow on the side of a nacelle. A flight test was designed to meet this goal and a brief review of the purpose is given. A nacelle with a significant length of laminar flow was mounted on the wing of NASA OV-1. Two noise sources are also mounted on the wing: one in the center body of the nacelle; the second in a wing mounted pod outboard of the nacelle. These two noise sources allow for a limited study of the effect of source direction in addition to control of the acoustic level and frequency. To determine the range of Tollmien-Schlichting frequencies, a stability analysis using the pressure coefficient distribution along the side of the nacelle was performed. Then by applying these frequencies and varying the acoustic level, a study of the receptivity of the boundary layer to the acoustic signal, as determined by the shortening of the length of laminar flow, was conducted. Results are briefly discussed. Author

N90-13198*# Douglas Aircraft Co., Inc., Long Beach, CA.
UHB DEMONSTRATOR INTERIOR NOISE CONTROL FLIGHT TESTS AND ANALYSIS Final Report
M. A. SIMPSON, P. M. DRUEZ, A. J. KIMBROUGH, M. P. BROCK, P. L. BURGE, G. P. MATHUR, M. R. CANNON, and B. N. TRAN Oct. 1989 188 p
(Contract NAS1-18037)
(NASA-CR-181897; NAS 1.26:181897) Avail: NTIS HC A09/MF A01 CSCL 20/1

The measurement and analysis of MD-UHB (McDonnell Douglas Ultra High Bypass) Demonstrator noise and vibration flight test data are described as they relate to passenger cabin noise. The analyses were done to investigate the interior noise characteristics of advanced turboprop aircraft with aft-mounted engines, and to study the effectiveness of selected noise control treatments in reducing passenger cabin noise. The UHB Demonstrator is an MD-80 test aircraft with the left JT8D engine replaced with a prototype UHB engine. For these tests, the UHB engine was a General Electric Unducted Fan, with either 8x8 or 10x8 counter-rotating propeller configurations. Interior noise level characteristics were studied for several altitudes and speeds, with emphasis on high altitude (35,000 ft), high speed (0.75 Mach) cruise conditions. The effectiveness of several noise control treatments was evaluated based on cabin noise measurements. The important airborne and structureborne transmission paths were identified for both tonal and broadband sources using the results of a sound intensity survey, exterior and interior noise and vibration data, and partial coherence analysis techniques. Estimates of the turbulent boundary layer pressure wavenumber-frequency spectrum were made, based on measured fuselage noise levels. Author

N90-13202# Rolls-Royce Ltd., Derby (England). Powerplant Technology Div.
THE DESIGN AND DEVELOPMENT OF AN ACOUSTIC TEST SECTION FOR THE ARA TRANSONIC WIND TUNNEL
M. E. WOOD and D. A. NEWMAN 15 Nov. 1988 63 p
(PNR90574; INR90259; ETN-89-95555) Copyright Avail: NTIS HC A04/MF A01

The structural, aerodynamic and acoustic design of a lined test section necessary to produce a sufficiently reflection-free environment for noise tests in the Aircraft Research Association (ARA) tunnel at Mach numbers up to 0.85 are described. The aerodynamic design was aided by computational fluid dynamics methods and the acoustic design by a ray-theory model. Results of the aerodynamic calibration of the liner and preliminary acoustic and performance tests on two model propellers are presented. Development work carried out to improve the liner acoustically and aerodynamically is described. ESA

N90-13203# Rolls-Royce Ltd., Derby (England).
THE COMMERCIAL AIRCRAFT NOISE PROBLEM
M. J. T. SMITH 15 Jan. 1989 11 p Presented at the Interdependenzen von Luftfahrt-Staedtebau-Umwelt, Fed. Republic of Germany, Jan. 1988
(PNR90577; ETN-89-95557) Copyright Avail: NTIS HC A03/MF A01

The history and future developments of commercial aircraft noise are discussed. The use of the turbofan engine to replace the louder turbojet engine is identified as a step forward in reducing noise. The increasing use of two engine planes for medium and even long hauls is seen as a positive trend. An increase in the number of aircraft movements is predicted. An upturn in noise exposure around the end of the century is predicted. The development goals of Rolls Royce in meeting the noise reduction challenges of the next decades are discussed. ESA

N90-13207# Royal Aerospace Establishment, Farnborough (England).
ACOUSTIC RECORDING SYSTEMS FOR USE IN MILITARY AIRCRAFT
K. HARPUR 24 Nov. 1988 25 p
(RAE-TM-MM-11; BR109026; ETN-89-95002) Copyright Avail: NTIS HC A03/MF A01

The recording systems used for inflight noise measurements inside military aircraft are described. The details of the equipment, its method of operation, possible measurement configurations and capabilities, are included. In particular, the following equipment is presented: the tape recorder, the microphone and microphone box, the telephone box, the alternative systems and the active noise reduction power supply unit. ESA

N90-13228*# Mesoscale Environmental Simulations and Operations, Inc., Hampton, VA.
MESOSCALE ACID DEPOSITION MODELING STUDIES Final Report, Jul. 1986 - Jul. 1989
MICHAEL L. KAPLAN, F. H. PROCTOR, JOHN W. ZACK, V. MOHAN KARYAMPUDI, P. E. PRICE, M. D. BOUSQUET, and G. D. COATS Washington Dec. 1989 114 p
(Contract NAS1-18336)
(NASA-CR-4262; NAS 1.26:4262) Avail: NTIS HC A06/MF A01 CSCL 04/2

The work performed in support of the EPA/DOE MADS (Mesoscale Acid Deposition) Project included the development of meteorological data bases for the initialization of chemistry models, the testing and implementation of new planetary boundary layer parameterization schemes in the MASS model, the simulation of transport and precipitation for MADS case studies employing the MASS model, and the use of the TASS model in the simulation

of cloud statistics and the complex transport of conservative tracers within simulated cumuloform clouds. The work performed in support of the NASA/FAA Wind Shear Program included the use of the TASS model in the simulation of the dynamical processes within convective cloud systems, the analyses of the sensitivity of microburst intensity and general characteristics as a function of the atmospheric environment within which they are formed, comparisons of TASS model microburst simulation results to observed data sets, and the generation of simulated wind shear data bases for use by the aviation meteorological community in the evaluation of flight hazards caused by microbursts. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

N90-12406# Systems Control Technology, Inc., Arlington, VA.
ROTORCRAFT LOW ALTITUDE CNS BENEFIT/COST ANALYSIS: ROTORCRAFT OPERATIONS DATA Final Report
BRIAN E. MEE, DEBORAH PEISEN, and MARGARET B. RENTON Sep. 1989 160 p
(Contract DTFA01-87-C-00014)
(DOT/FAA/DS-89/9; SCT-89RR-47) Avail: NTIS HC A08/MF A01

Communications, navigation, and surveillance (CNS) services are readily available at the altitudes flown by most fixed wing aircraft. They are not, however, always available at the ower altitudes at which most rotary wing aircraft operate. The objective is to determine if there is an economic basis for improvement of these low altitude CNS services within the National Airspace System (NAS) in order to better support rotorcraft operations. The Rotorcraft Master Plan advocates the establishment of additional CNS facilities as well as the analysis and development of systems to satisfy the increasing demand for widespread IFR rotorcraft operations within the NAS. The findings will aid the FAA decisionmaking in that regard. In view of prior implementation decisions on Loran-C, the emphasis is on communications and surveillance. Background data is provided on the rotorcraft industry as it exists today, as well as forecasts to the year 2007 for the purpose of providing operational data for analysis of long term CNS benefits and costs. Rotorcraft missions are described; those most likely to benefit from increased availability of CNS services are selected; the probability is identified of various combinations within selected rotorcraft operating areas; and an inventory is presented of rotorcraft activity by mission and location. Author

N90-13278# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction des Grands Moyens d'Essais.
STUDIES OF THE EUROPEAN TRANSONIC WIND TUNNEL Final Report [ETUDES DE LA SOUFFLERIE TRANSSONIQUE EUROPEENNE]
X. BOUIS Dec. 1988 16 p In FRENCH
(Contract DRET-88-817)
(ONERA-RSF-12/0694-GY; ETN-89-95019) Avail: NTIS HC A03/MF A01

The stages of planning and development of the European transonic wind tunnel are described. Progress in resolving budgetary and technical problems is outlined. Changes in administration and personnel involved in the project are listed. Contracts and costs involved in the project are outlined. An operating scenario is presented. An hierarchical list of the different sectors and managers involved in the project is provided. ESA

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GENERAL

A90-13700#
'BLACK BETSY' - THE 6000C-4 ROCKET ENGINE, 1945-1989.
FRANK H. WINTER IAF, International Astronautical Congress, 40th, Malaga, Spain, Oct. 7-13, 1989. 41 p. refs
(IAF PAPER 89-726)

The rocket powerplant used by the sound barrier-breaking X-1 aircraft in 1947, designated 6000C-4 but popularly known as the 'Black Betsy', is presently shown to have proceeded on a career spanning 45 years. After powering a dozen additional experimental aircraft for high speed research, an uprated version of the 6000C-4 served as the engine for the MX-774 test missile that was a precursor to the Atlas ICBM. A pair of the standard C000C-4 constituted the interim powerplant for the X-15 hypersonic research vehicle prior to the XLR-99 rocket engine's development; in the 1970s, Black Betsies furnished propulsion for various 'lifting body' research vehicles. O.C.

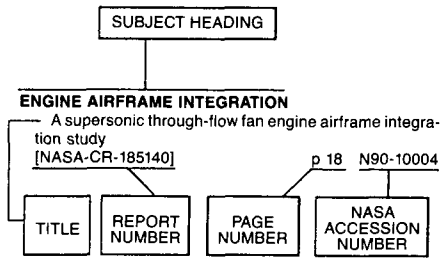
A90-16300
KEEPERS OF THE FLAME
T. A. HEPPENHEIMER Air and Space (ISSN 0886-2257), vol. 4, Dec. 1989-Jan. 1990, p. 88-95.
Copyright

A development history is presented for the emergence of supersonic combustion ramjet, or 'scramjet' concepts from ramjet research, with emphasis on the extent to which military interest and funding has paced and sometimes retarded this avenue of advanced propulsion research. Scramjets are able to generate thrust efficiently at speeds above Mach 5, and perhaps as high as the Mach 25 required (at extreme altitudes) to enter earth orbit. Scramjets typically use liquid hydrogen fuel, which is uniquely capable of diffusing into their supersonic internal flow and combusting at comparable speeds. O.C.

N90-12494# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
ON THE OCCASION OF THE 100TH BIRTHDAY OF ERNST HEINKEL [ZUM 100. GEBURTSTAG VON ERNST HEINKEL]
H. DIETER KOEHLER and HANS J. EBERT, ed. 1988 49 p In GERMAN
(MBB/LW/3015/S/PUB/321; ETN-89-94614) Avail: NTIS HC A03/MF A01

On the occasion of the one hundredth birthday of Ernst Heinkel, it's contributions to the German aerospace development and industry, and international aviation are outlined, including the aircrafts He70, He111, He112, He176, He177, He118, He274, He116, He119, He115, He59, He114, He60, He59, He100V8, He280, He280V1. ESA

Typical Subject Index Listing



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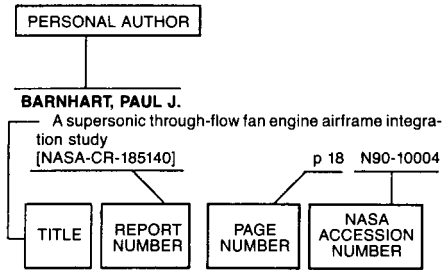

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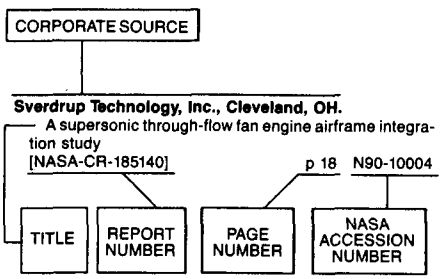

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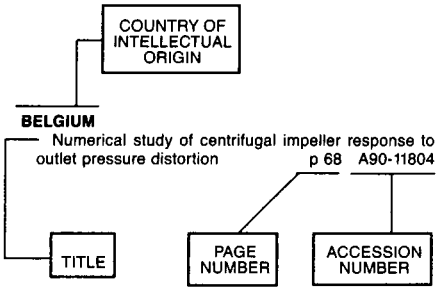

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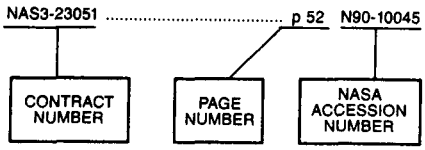

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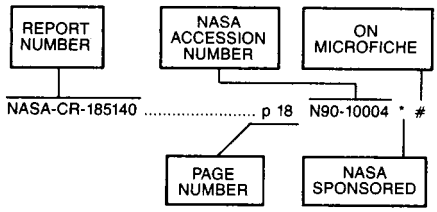

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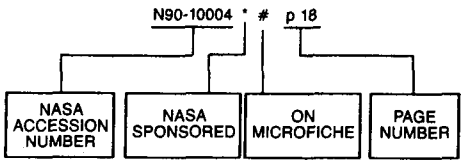

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